COMPREHENSIVE FRAMEWORK STUDY

CALIFORNIA REGION

APPENDIX XVI

Shoreline Protection and Development

JUNE 1971

Prepared by:
California Region Framework Study Committee
For Pacific Southwest Inter-Agency Committee
Water Resources Council

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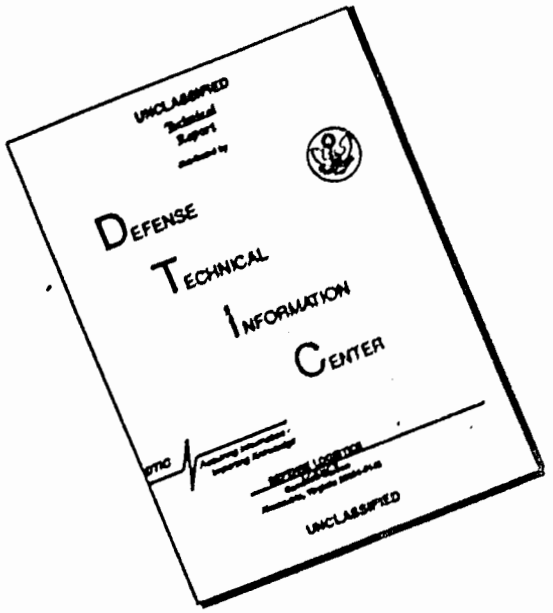

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Main Report
Appendixes

I	History of Study
II	The Region
III	Legal and Institutional Environments
IV	Economic Base and Projections
V	Water Resources
VI	Land Resources and Use
VII	Mineral Resources
VIII	Watershed Management
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X	Irrigation and Drainage
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XVIII	General Program and Alternatives

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COMPREHENSIVE FRAMEWORK STUDY,

CALIFORNIA REGION,

APPENDIX XVI,

SHORELINE PROTECTION AND DEVELOPMENT,

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This report of the California Region Framework Study Committee was prepared at field level and presents a framework program for the development and management of the water and related land resources of the California Region. This report is subject to review by the interested federal agencies at the departmental level, by the Governors of the affected states, and by the Water Resources Council prior to its transmittal to the Congress for its consideration.

June 1971

Prepared by the
California Region Framework Study Committee

For the

Pacific Southwest Inter-Agency Committee
Water Resources Council

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National Park Service photo

"All the coast passed this day is very bold; there is a great swell and the land is very high. There are mountains which seem to reach the heavens, and the sea beats on them; sailing along close to land, it appears as though they would fall on the ships...."

Juan Rodriguez Cabrillo, 1542

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CALIFORNIA REGION

COMPREHENSIVE FRAMEWORK STUDY

APPENDIX XVI - SHORELINE PROTECTION AND DEVELOPMENT

INTRODUCTION

Purpose and Scope

GENERAL

This appendix concerns itself with the needs for protection and development of the shoreline zone. The shoreline zone is considered to include the area subject to erosion from sea action and the closely adjoining landward area and comprises a strip generally not exceeding 500 feet in width. It extends along the entire coastline of the California Region, including major bays, estuaries and offshore islands.

DEFINITION OF TERMS

In this appendix, shoreline protection refers to structural and non-structural measures to alleviate erosion damage along the shoreline. Examples of structural measures are protective beaches, seawalls, and revetments. Examples of non-structural measures are zoning and management of the shoreline zone. Shoreline development refers to structural measures to provide additional recreational beaches through beach widening and construction of peninsular extensions of the shoreline.

Recreational shoreline has been considered in three categories -- swimming beach, non-swimming beach, and scenic shoreline -- defined generally in accordance with definitions used in the "California State Park System Plan." These definitions are as follows:

(1) Swimming beach is sandy, gently sloping beach with ocean temperatures not lower than 60° June through September.
(2) Non-swimming beach includes cold-water beaches, whether otherwise suitable for swimming or not; steep, sandy beaches unsafe for swimming; and rocky, cobbly and pebbly beaches.
(3) Scenic shoreline is natural, relatively pristine shoreline with significant scenic, scientific or ecologic values.

The shoreline has been classified in three categories in respect to its erodibility. Non-erodible shoreline comprises shoreline composed of resistant rock, shoreline protected by harbor structures, or beach-erosion-control improvements and shoreline that is accreting or stable. Non-critical shoreline erosion comprises erosion of uninhabited areas, except where loss of recreational swimming beaches is involved. Critical shoreline erosion comprises erosion that threatens shoreline resources and urban or public facilities, and requires structural or non-structural measures for protection.

ASSUMPTIONS

Some assumptions have been made in this study to reduce the problem to manageable proportions. These assumptions are:

(1) Future wave-energy spectra will closely resemble present wave-energy spectra.
(2) When man-made structures are built in the shoreline zone, mitigative measures will be provided as part of the development so as not to interrupt the natural littoral transport process.
(3) Waste disposal in the ocean, including thermal waste, will meet future water quality standards and will not adversely affect the shoreline zone.
(4) Problems associated with thermal electric power and desalinization plants, sewage treatment plants, etc., will be resolved so as not to adversely affect the shoreline zone.
(5) Problems associated with offshore-petroleum production will be resolved so as not to adversely affect the shoreline zone.
(6) Protection and development work in the shoreline zone will include measures to mitigate adverse effects on the ecology.
(7) Public access to the shoreline zone within Federal military reservations will be permitted in the future where such access does not interfere with the basic military mission.
(8) Conflicts between proposals made in this appendix and beneficial uses of the shoreline proposed in other appendices will be mutually resolved.

The varied scenery at Point Reyes National Seashore includes both vast reaches of sandy beach and rugged cliffs.
(National Park Service photos)

SHORELINE USES

This report emphasizes activities that are best met in the shoreline zone. Various shoreline uses and activities are listed below.

Uses of the Shoreline

- Harbors, terminals, and services for commercial shipping
- Harbors, terminals, and services for commercial fishing boats
- Recreational harbors
- Lighthouses, marine radio stations, and other aids to navigation
- Transoceanic communications lines
- Transportation pipelines
- Shoreline recreation, such as swimming, surfing, SCUBA diving, fishing, enjoyment of scenic shoreline
- Propagation of biologic resources
- Scientific research
- Education and research institutions dealing with the sea and the shoreline
- Military and space facilities requiring a sea-land environment
- Commercial uses, such as waterfront restaurants, marine aquariums, boat launching facilities, etc.
- Residential-commercial developments
- Industrial facilities, including power-generating plants; petroleum production, refining and storage facilities; etc.
- General recreation, such as camping, picnicking, etc.
- Specialized farming
- Production and processing of lumber and wood products

Some serious conflicts arise among the activities listed above. Some conditions in commercial harbors can impair their suitability for recreation; petroleum pipelines can break, causing beach pollution; military activities usually do not permit public use of the shoreline; waste disposal can adversely affect biological resources. However, significant possibilities exist for multiple-purpose developments in the shoreline zone. For instance, an offshore-recreational harbor could incorporate facilities to serve fishing boats and oceanographic research vessels, enhance surfing, add new beach, increase biologic resources through habitat-reefs, and provide an area for educational and commercial developments oriented to the marine environment. Concentration of man's impact upon the shoreline in the smallest area possible, through multiple-purpose projects, would permit preservation of more shoreline in its natural state.

Relationship to Other Parts of Report

GENERAL

This appendix is a unit of the Comprehensive Type I Framework Study for the California Region. The California Region includes the State of California plus a small portion of the State of Oregon. The Framework report has 18 appendices, assigned to appropriate technical subcommittees. The first three appendices are "History of Study," "The Region," and "Legal and Institutional Environments," and are essentially background material. The next four appendices are "Economic Base and Projections," "Water Resources," "Land Resources and Use," and "Mineral Resources"; these four appendices present basic information on the Region. The next 10 appendices are "Watershed Management," "Flood Control," "Irrigation and Drainage," "Municipal and Industrial Water," "Recreation," "Fish and Wildlife," "Electric Power," "Water Quality, Pollution and Health Factors," "Shoreline Protection and Development," and "Navigation." These 10 appendices may be termed functional appendices, as each deals with a particular recognized phase of water and related land use, development, or management. The final appendix, "General Program and Alternatives" brings together the resources and demands, or goals, and presents a framework plan and alternative plans of how the demands or goals can best be satisfied or achieved.

Study areas covered in other appendices to the report on the California Region are directly related to the Shoreline Protection and Development Appendix. The most significant of these relationships are discussed in the following paragraphs.

LEGAL AND INSTITUTIONAL ENVIRONMENTS

Existing Federal and State statutory authorities are generally adequate for the implementation of present shoreline policies, but additional legislation may be required to support future policy modifications. The studies recommended in Appendix III: Legal and Institutional Environments, would provide valuable guidance in developing these policy modifications.

LAND RESOURCES AND USE

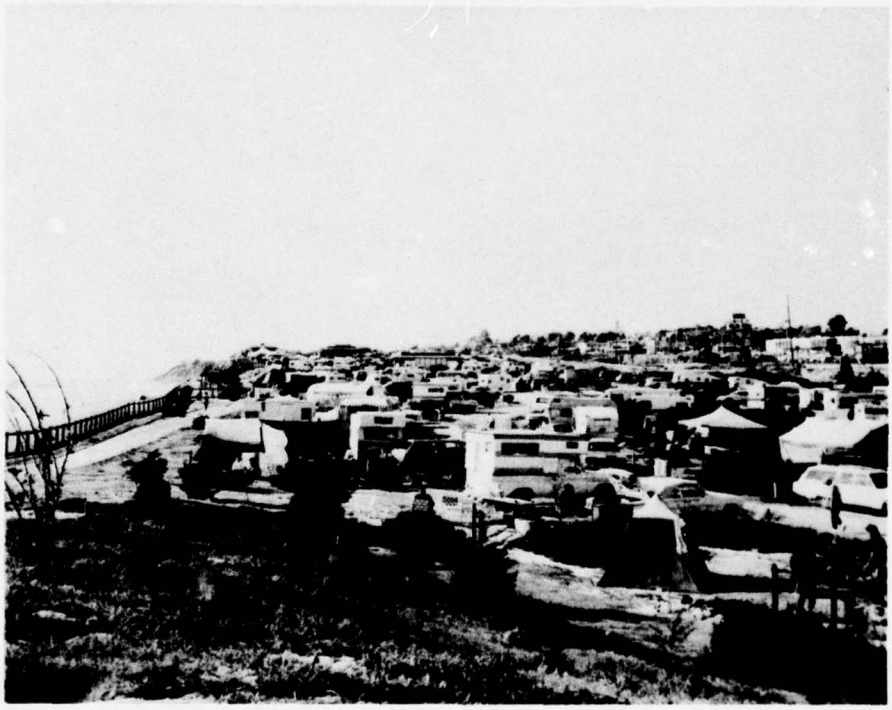
The entire problem of land use and its relation to natural resources, including the coastal zone, is made up of close interrelationships and interactions. Coastal areas subject to natural erosion by the sea will probably have their protection needs determined by the value of the improvements needing protection, and by the priority for protection expressed by needs of the current society. The final decisions on shoreline protection will also be dependent on existing and proposed uses of the upland areas.

(Photo by Tom Myers)

The shoreline zone provides various types of recreation, such as boating, fishing from harbor structures, and surfing. These photographs were taken in the South Coastal subregion.

(Corps of Engineers photo)

This rock formation is at Natural Bridges State Beach, in Santa Cruz County (Central Coastal subregion). Erosion has produced this unique scenic feature.
(State of Calif. Dept. of Parks and Recreation photo)



During the vacation season, beach camp grounds, such as this one at San Elijo State Beach in San Diego County, have their spaces reserved months in advance.
(State of Calif. Dept. of Parks and Recreation photo)

Fishing is a major shoreline recreation in the North Coastal subregion. These fishermen are on the sandspit at the mouth of the Klamath River awaiting the start of the salmon run.
(Corps of Engineers photo)

These camping sites provide enjoyment of scenic coastal vistas. This campground is in the Los Padres National Forest, in the Central Coastal subregion.
(U.S. Forest Service photo)

WATERSHED MANAGEMENT

Erosion control and sediment reduction could result in reducing the amount of beach building material reaching the shoreline.

MINERAL RESOURCES

Extraction of mineral resources from submerged coastal area is, with the exception of petroleum, an infant industry. Possible adverse effects of offshore-petroleum production have received increasing public attention, particularly since occurrence of the highly publicized well blowout in the Santa Barbara Channel in 1969. Effects of massive oil spills upon the shoreline and efficacy of control measures are yet to be fully evaluated. Mining of the continental shelf for gold, manganese, or other minerals, probably will occur in the future. Unregulated disposal of waste material from offshore-mining operations could adversely affect the shoreline ecology; on the other hand, suitable waste material could be advantageously used for widening or protecting beaches.

FLOOD CONTROL

A few flood control structures in the California Region may have produced adverse effects on the shoreline regimen. In some localized areas, sediment contribution has been reduced, the beaches have been noticeably affected, and mitigative measures may be required. The majority of flood control measures in the Region, such as the large dams and channel improvements in the Central Valley of California, have produced no apparent effect on the shoreline.

RECREATION

The recreation directly afforded by the shoreline includes swimming, sun bathing, surfing, SCUBA and free diving, camping, fishing, tidepool exploration, and many other activities. Extensive recreational improvements are required to permit realization of the full recreational potential of the shoreline. These developments include provision of adequate parking, or equivalent facilities, to permit full use of beaches and other shoreline; campgrounds and picnicking facilities; shoreline access; vista points; and supporting commercial facilities.

FISH AND WILDLIFE

A part of the recreation afforded by the shoreline is dependent upon biologic resources. Surf fishing, clam digging, and tidepool exploration are recreations dependent upon shore life. However, many other types of recreation are enhanced by the presence of gulls, pelicans, shore birds, sea otters, sea lions, and other animals peculiar to the shoreline. Protection of the shoreline, its ocean, bays, and estuaries, may also assist in

perpetuating the animals unique to these habitats. In addition, some resources harvested by commercial fishermen are totally dependent upon this inshore habitat.

ELECTRIC POWER

Power-generating plants, whether using fossil or nuclear fuels, require large volumes of cooling water. In the generally arid southern part of the Region, many of these plants are located near the shoreline because of the economic advantages created by the use of ocean water for cooling. This use of the shoreline may have both adverse and beneficial side effects. For example, at Morro Bay, the power plant adversely affects aesthetics by dominating Morro Rock; but, contrariwise, the plant's warm water discharge greatly improves sport fishing. Future power plants should be sited and constructed to both minimize their effect on the scenery and optimize their effect on shoreline recreation.

WATER QUALITY, POLLUTION CONTROL, AND HEALTH FACTORS

The effects of waste disposal in the ocean, including thermal wastes, pesticides, fluid wastes, and solid wastes, have not been fully determined. Studies in this area are recommended if waste discharges are to continue. Waste disposal in bays and estuaries generally modify biological resources. Water quality standards must be enforced to protect beneficial uses, including fish and wildlife habitat, sport and commercial fishing, water contact sports, navigation, industrial water supply, scientific research and aesthetic enjoyment.

NAVIGATION

In subregions where the pressure on shoreline resources is particularly high, conflicts have arisen as a result of competing recreational needs for boating facilities and beaches. Small-craft harbors generally withdraw shoreline for this single-purpose use, making it unavailable for uses other than recreational boating. Navigation structures may affect the littoral transport regimen of adjacent shoreline, requiring associated mitigative measures.

History of Regional Development

Many of California's aboriginal inhabitants were dependent upon fish, shellfish, and aquatic mammals for their food; hence, their settlements were located along much of the shoreline. The islands off the southern coast may be one of North America's first inhabited regions. The Spanish explorers, and later settlers, were concerned primarily with navigational aspects of the shoreline, and found the broad, sandy beaches as inhospitable as the rocky shoreline. The first modifications of the shoreline were made to improve navigation, starting with the earliest

Federal project in 1852 for improvement of San Diego Harbor. The needs of navigation and commerce dominated use of the shoreline until the turn of the 20th century, when the region's inhabitants turned to the shoreline for recreation.

In the early 1900's, many summer-resort communities were established along the beaches and at other scenic and accessible coastal sites. The first beach settlements were summer cottages; however, permanent homes and improvements followed. Oil had been discovered in coastal areas of southern California near the turn of the century, adding oil wells, tank farms, and refineries to the coastal environment. In 1927, the State Division of Beaches and Parks was established and acquisition of coastal public lands for recreation began. In 1930, the Congress authorized the Corps of Engineers to investigate shore processes and beach erosion problems in cooperation with the States. World War II saw the establishment and expansion of many coastal military reservations and facilities, and the start of a population explosion, particularly in the coastal areas. As the population rose, the investment in shoreline properties increased, and man began to notice through damage to his properties, that the shoreline was often extremely variable. Many structures built to protect one area, or to provide necessary navigation facilities, often caused drastic changes in adjacent shorelines. Public concern was manifested in the need to provide public shoreline recreation areas and in the need to prevent loss of land and structures through shoreline erosion.

The first Federal beach erosion control project in California, at Seal Beach in Orange County, was authorized in the early 1950's. Since then, about 26 miles of cooperative State-Federal shore-protection works have been constructed.

There is a growing concern for the preservation of the amenities of the shoreline for recreation and conservation of this shoreline for future generations.

Prior Planning and Legislative Actions

A brief summary of planning and legislative actions taken to date in respect to the shoreline of the California Region is presented as background. Early in 1964, the Governor of California held a conference on "California and the World Ocean." As an outgrowth of this conference, the Governor's Advisory Commission on Ocean Resources (GACOR) was created. The commission was comprised of representatives from various governmental levels, the private sector, and educational and research institutions. The primary objective of GACOR was to review the relationship of the ocean and its resources to the State and its people, and to evaluate the State's goals and commitments in ocean resource development.

In October 1965, the Institute of Marine Resources of the University of California published a comprehensive planning study, "California and Use of the Ocean." The objectives of this study were (a) to review interrelationships between the sea and its resources and the State and its people; (b) to evaluate the uses of ocean resources and to identify conflicts between uses; (c) to examine the possibility of modifying the marine environment for various development purposes; (d) to examine and evaluate the State's governmental responsibility in developing and conserving marine resources; and (e) to recommend policy and to indicate areas where more information is needed to provide a basis for policy decisions. This report was a major first step toward development of the comprehensive master plan called for by the Governor.

In May 1966, the Resources Agency of the State of California established the Resources Agency Committee on Ocean Resources (RACOR). RACOR was composed of members from all departments in the State's Resources Agency. Its function was to respond to a number of recommendations and directives, including the Governor's directive issued at a Resources Agency Conference in 1966 calling for a coordinated marine resource management program, and the directive contained in California Senate Resolution 150 calling for the development of a program for management of sport and food marine resources. RACOR also responded to recommendations contained in the reports issued by the Institute of Marine Resources, GACOR, the California Fish and Wildlife Plan, the California Outdoor Recreation Plan, the California Boating Plan, and in marine-oriented proposals made by other agencies. In December 1966, RACOR published a report "California and the Ocean." The first section of this report presents the uses of the ocean, with a projections of demands into the future. The second section contains recommendations for a procedure under which a comprehensive use plan for ocean resources can be developed, and includes recommendations on the organization and conditions under which the plan should be prepared and implemented. The third section of the RACOR report presents the details of programs to handle certain priority problems of the ocean. These programs include salt water conversion, marine fisheries research, geology and mineral mapping, water quality control, transportation on marine waters, beach erosion, and recreational-shoreline development. December 1966 also saw publication of the compilation of recommendations by GACOR.

RACOR recommended that an Interagency Council on Ocean Resources (ICOR) be created and that an Ocean Planning Group be established to act as staff to ICOR. ICOR was created by the Governor of California in August 1967.

In March 1969, by a reorganization of the Executive Branch of the California State Government, a new department of the Resources Agency was created. This department, the Department of Navigation and Ocean Development, was given major responsibility for ocean-oriented activities, including functions concerned with harbors, boating facilities and beach erosion.

The Department of Navigation and Ocean Development is now engaged in preparing a "Comprehensive Ocean Area Plan" (COAP) designed to be the official expression of the State's interests and objectives in its coastal zone. The COAP is scheduled for publication in 1972, to serve as the basis for continuing policy and state government action to plan and manage orderly development and conservation of the coastal zone.

Recent Federal studies pertaining to the shoreline area are "Our Nation and the Sea - A Plan for National Action," "The National Estuary Study," "Islands of America" and the National Shoreline Study. The first three studies have been completed and published; the National Shoreline Study is scheduled for completion in 1971.

"Our Nation and the Sea - A Plan for National Action" was produced in early 1969 by the Commission on Marine Science, Engineering and Resources, which was established by legislation in 1966. The plan included the following key proposals:

(a) Establishment of a National Oceanic and Atmospheric Agency (NOAA) to be the principle instrument for administration of the nation's civil marine and atmospheric programs. This agency has since been established under the Department of Commerce.

(b) The enactment of a Coastal Management Act to provide policy objectives for the coastal zone and authorize Federal grants-in-aid to facilitate the establishment of state coastal zone authorities with powers of planning, zoning, acquisition and development of public facilities along the shoreline.

"The National Estuary Study" was produced in 1970 by the Department of the Interior, Fish and Wildlife Service in response to the Estuary Protection Act (Public Law 90-454). While pointing up the unique value of the resource to vast numbers of Americans, the study also concluded that the destruction of our estuaries is proceeding at a rate that will mean their demise in a few decades. The report does not make any specific recommendations beyond urging that the proposed coastal zone management system be oriented towards protection of fish and wildlife resources, associated commercial fishing and outdoor recreation activities and natural area preservation. Federal support is suggested for needed acquisitions of areas of such value that their protection is essential.

"Islands of America," a 1970 study by the Department of the Interior, Bureau of Outdoor Recreation, stresses the potential recreation values of our island resources. The study specifically recommends Congressional action to authorize the proposed Channel Islands National Park.

The National Shoreline Study was authorized by 1968 River and Harbor Act (Public Law 90-483). The National Shoreline Study has the following objectives: (a) to determine where erosion occurs; (b) to identify areas

where erosion is a sufficiently serious problem, because of its effects on any shoreline use, to warrant action to halt erosion; (c) to determine the most suitable or remedial action for areas with serious erosion problems; (d) to provide preliminary costs estimates for remedial action; (e) to recommend priorities for action to halt erosion; (f) to provide State and local authority with recommendations to assist in creation and implementation of State and local programs; (g) to develop guide lines for land use regulation in coastal areas, considering all relative factors; and (h) to identify coastal areas where tidal uncertainty exists.

In addition to the planning and legislative organizations concerned with the general ocean and marine area, the Bay Conservation and Development Committee, created in September 1965 by the McAteer-Petris Act of the State Legislature, was charged with the specific responsibility for "a comprehensive and enforceable plan for the conservation of the waters of San Francisco Bay and the development of its shoreline." The Committee published the "San Francisco Bay Plan" in January 1969. The major conclusions in that report were (a) that the Bay must be considered a regional resource; (b) that filling of the Bay should be limited to essential fill providing substantial public benefit; and (c) that shoreline areas suitable for priority uses, such as ports, water-related industries, airports, wildlife refuges, and recreation areas, are limited and should be reserved for these purposes. The "San Francisco Bay Plan" recommended that a governmental agency be created or designated to carry out the Bay Plan through a permit system for bay filling and dredging and for shoreline development. This agency, The San Francisco Bay Conservation and Development Commission, was created by the California State Legislature in November 1969.

Shoreline Processes and Erosion Control

SHORELINE PROCESSES

Major sources of beach-building material have been natural processes of coastal erosion and stream transport in drainage basins tributary to the ocean. The natural sand supply from tributary drainage basins is dependent on the rate of upland erosion and on the ability of streams to transport material. Many factors can affect the sand supply; for instance, cyclical dry spells can result in insufficient runoff to carry material to the ocean. Urbanization can have an adverse effect on the natural sand supply through reducing the erodible area and requiring that storm runoff be contained by storm drains, flood-control channels, debris basins, and dams. Some flood control improvements, such as those on San Juan Creek in southern California, have increased the supply of sand to the coast by eliminating sand deposits in overflow areas and also by providing higher flow velocities than existed under natural conditions.

Once beach-building material has reached the littoral zone, it is acted upon by wave action and is sorted and formed into a beach. Beach sand is moved onshore or offshore, usually seasonally, by the uprush and backwash of the waves; and can also be moved along parallel to shore by the littoral current. The littoral current results when ocean waves strike the shoreline at an angle. Littoral current is diagrammed in Figure 1.

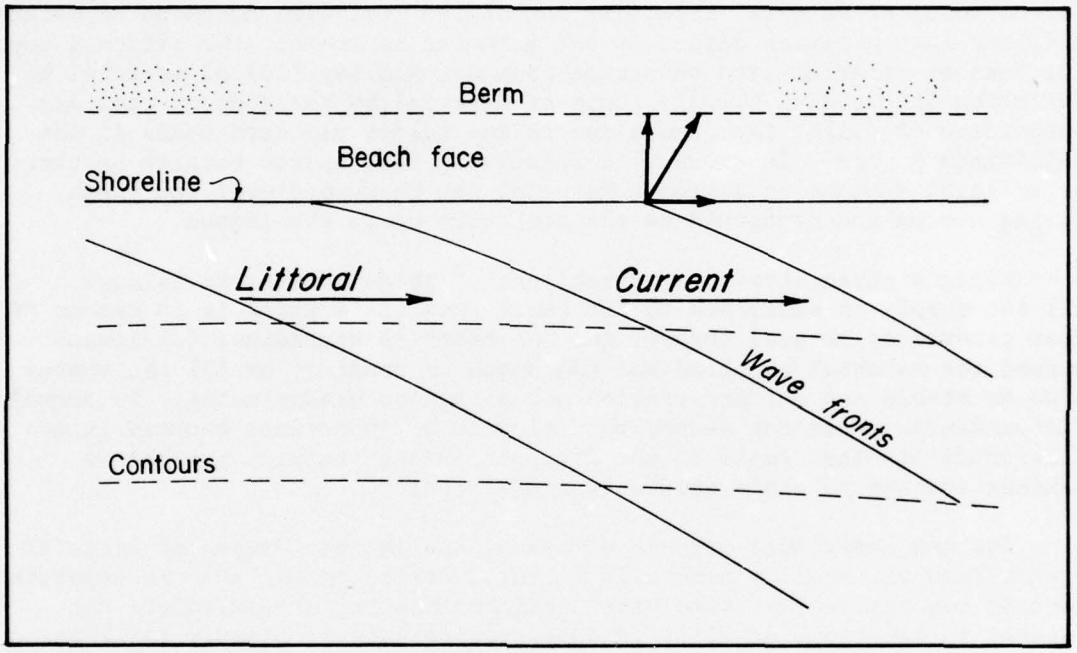


FIGURE 1 - LITTORAL CURRENT

Angular wave train approach results from a combination of circumstances, including the location of mid-ocean winds producing the waves, the orientation of the coastline, and the effects of sheltering islands. The impinging waves have an energy and wave motion component parallel to the shoreline. This motion, the littoral current, is responsible for the movement of beach sand (littoral drift) along the coast. The littoral current may change seasonally from upcoast to downcoast, as waves approach from different directions. When more material is moved downcoast than upcoast during a one-year period, the direction of net littoral transport is said to be downcoast.

Another source of beach-building material is erosion of coastal formations by the sea. This source is locally important because some coastal formations contain large amounts of beach building materials.

The four main natural sources of material to any specific beach segment are: (1) material moving into the area by littoral transport from adjacent beach areas; (2) contributions by streams; (3) contributions through erosion of coastal formations other than beaches exposed to wave attack; and (4) movement from offshore areas. Considering coasts as a whole, maintenance of beaches by natural processes is attained at the expense of erosion of the land mass.

Losses of beach material from a specific area result primarily from: (1) movement of material laterally out of the area; (2) movement of material offshore into water so deep that the material is lost to the littoral supply; (3) loss of material into submarine canyons; and (4) loss of material by deflation (i.e., wind blown). Loss of material by abrasion of sand has been found of slight importance due to the relatively hard sands in the California Region. In areas with relatively low, narrow barrier beaches, significant amounts of littoral material may be washed over the dunes during storms and deposited on the backshore or in the lagoon.

Along a given stretch of beach, one of three conditions exists: (1) the supply of sediments to the beach from all sources is in excess of that removed by natural forces, and the beach is aggrading; (2) losses exceed the material supplied and the beach is eroding; or (3) the shoreline is stable and neither erosion nor accretion predominates. In normal circumstances, only the second condition is of importance because it is this condition that leads to the disappearance of natural protective beaches and the possible destruction of property.

For any individual segment of beach, the largest source of material moving into the area is generally littoral drift eroded from the adjoining updrift segment; unless some major sediment-bearing stream enters the segment in question, or cliff or dune erosion is sufficiently rapid to provide appreciable supply. The various procedures for beach stabilization or construction require consideration of the littoral currents and frequently include structures to modify the currents' transporting capability. Any intrusion into the littoral current will cause a temporary interruption of the sand movement until a realignment of the shoreline produces a new littoral equilibrium.

SHORELINE EROSION CONTROL

The term "beach" can be applied to any shoreline formation of sorted rock fragments. These fragments may be boulders, cobbles, gravels, sands, silts or clays. The slope of the beach foreshore and the erodibility of the beach are functions of the type of material comprising the beach. Boulders will stand on a steeper slope and will require greater wave energy to displace than sands.

The sandy beaches have received most of the attention because they represent the most-used recreational beaches and because they are most vulnerable to erosion. In the following discussion, it is primarily sandy beaches that are being considered.

Beach areas can be maintained by continuing the supply or by minimizing the loss of sand. When the supply is deficient, it can be augmented by artificial means. This replenishment can be accomplished by depositing sand either directly on the area of interest or into the littoral stream and allowing it to be naturally transported to the area. The source of the sand can be an upland excavation, an offshore underwater deposit, coastal sand dunes, or accretions formed by a littoral barrier such as a breakwater or groin. The process of moving littoral accretion around a barrier and back into the littoral stream is termed bypassing. Shoreline improvements that include structures such as harbor breakwater will normally require provisions for sand bypassing at regular intervals, ranging from one to several years, depending on the quantity of accretion and the severity of downdrift erosion.

As long as there is an adequate beach to dissipate the wave energy, the upland areas and improvements are protected, and space for recreation is available on the beach. In areas where replenishment is not feasible, other structural methods must be used to retain the beach. The problem then becomes one of design, where, through analysis of the wave forces in the littoral zone and the littoral transport characteristics, the proper type and configuration of structures can be selected.

SHORE PROTECTION STRUCTURES

The two major methods of dealing with beach erosion problems are stabilizing beaches with groins and periodic replenishment of beach material. A groin is a barrier-type structure designed to trap or retard passing littoral drift. Groins are usually built perpendicular to the shore, and extend from a point landward of possible shoreline recession into the water a sufficient distance to stabilize the shoreline. Depending on the desired results and the existing conditions, the length of the groin can be from less than 100 feet long to over 700 feet long. As material accumulates on the updrift side of the groin, supply to the downdrift shore is reduced and the downdrift shore recedes. This results in a progressively steepening slope on the updrift side and a flattening slope on the downdrift side, since both slopes must reach a common elevation at or near the end of the groin. Since the grain size of the beach material normally increases to establish a steeper than normal slope, the residual accreted material is probably, by selective processes, the coarser fraction of the material that was in transport. When the accreted slope reaches ultimate steepness for the coarser fraction of the material available, impoundment ceases and all littoral drift passes the groin. The accretion fillet on the updrift side of the groin creates a departure from normal shore alignment, tending toward a stable alignment

normal to the resultant of wave attack. The impounding capacity of the groin is thus dependent upon both the stability slope and stability alignment of the accretion fillet. These in turn depend upon characteristics of the littoral material and the direction of wave attack. The effects of a groin system are shown on Figure 2.

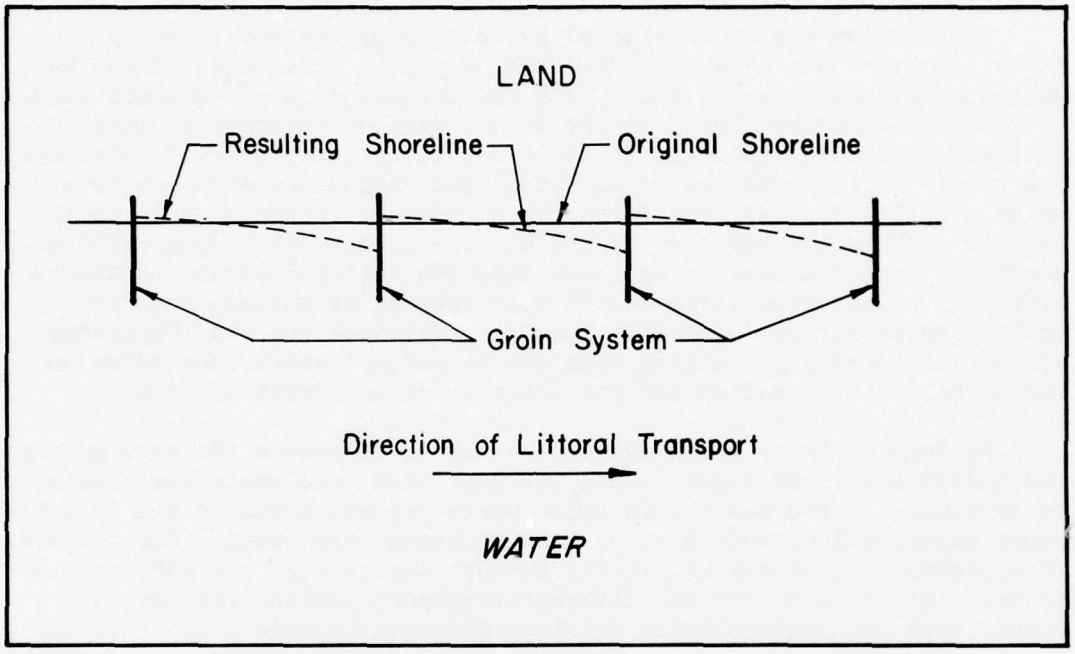


FIGURE 2 - EFFECT OF GROIN SYSTEM

Periodic replenishment involves adding new sand to the beach to replace material lost by erosive processes. The new sand may be brought from inland sources or from offshore sources. Inland sources may be sand deposits with suitable characteristics or dune fields; however, dune fields presently or prospectively providing secondary defense against overtopping by storm waves should not be considered a source of replenishment material. Offshore sources are deposits of beach material lying in depths of water that permit dredging of the material. Another localized source of material is littoral material accidentally or intentionally trapped by harbor structures. Some small-craft harbors have incorporated "sand traps" to deliberately collect littoral drift before it shoals harbor channels. The material collected in the sand trap can then be pumped to the downdrift beaches for nourishment. The offshore breakwaters used to form these sand traps are probably the most effective means of completely intercepting the littoral material and are usually positioned in water significantly deeper than the seaward ends of groins. This makes it possible for them to control a wider zone of littoral transport than structures tied to the shore. Because littoral transport is the direct

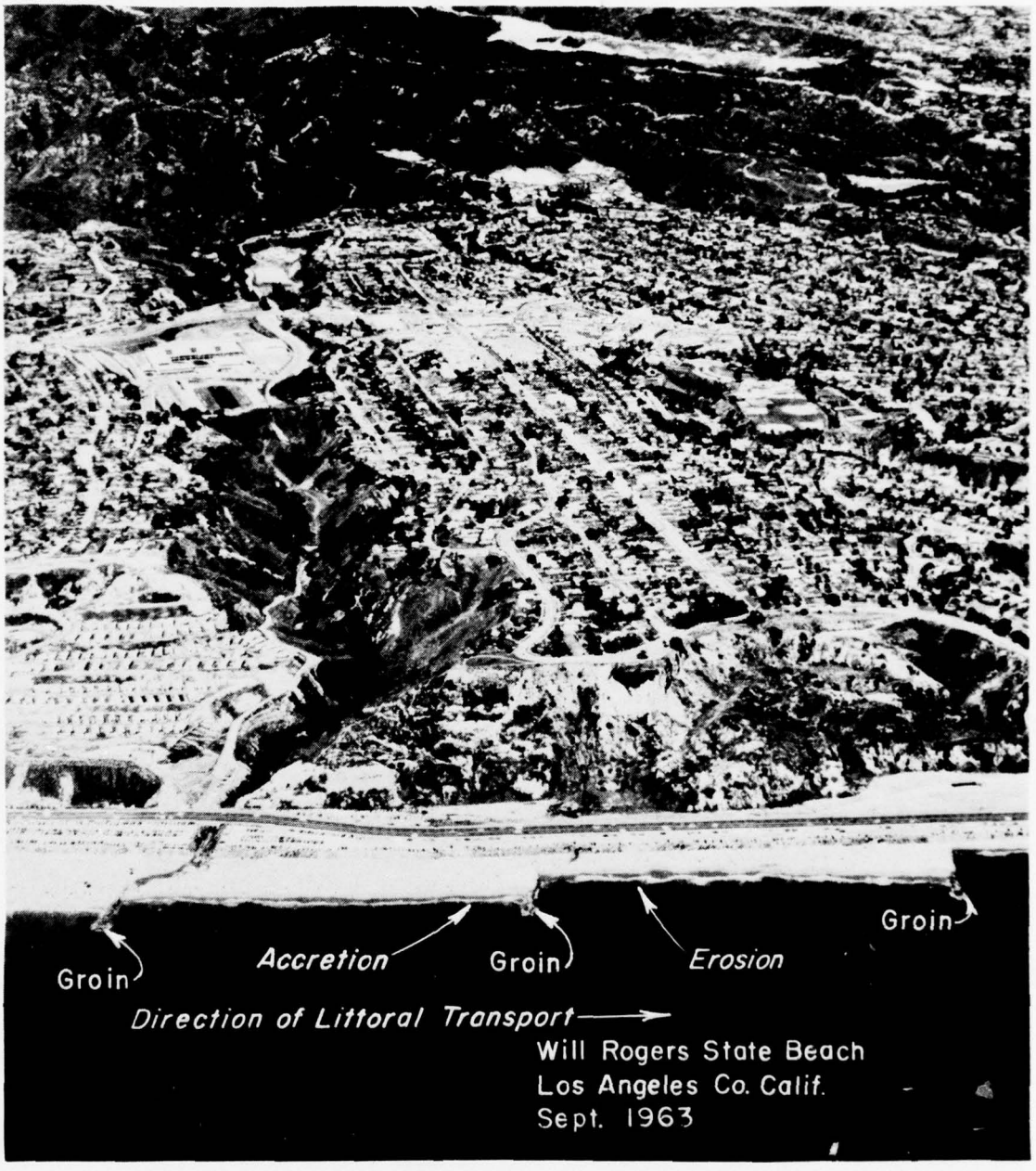


FIGURE 2A - PHOTO SHOWING EFFECT OF GROIN SYSTEM.

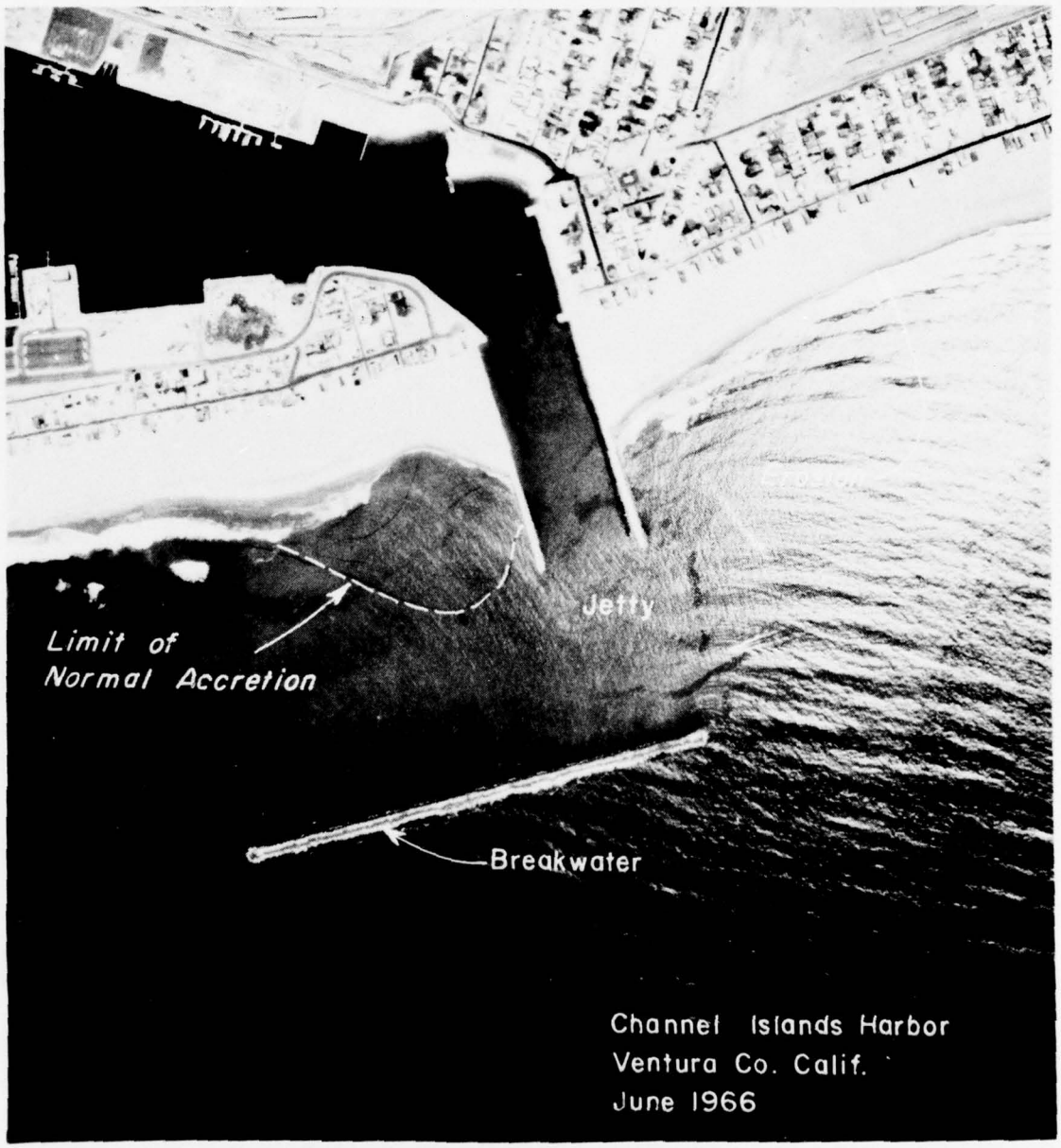


FIGURE 3A - PHOTO SHOWING EFFECTS OF OFFSHORE BREAKWATER.

result of wave action, the extent to which the breakwater intercepts the littoral drift is directly proportional to the extent of wave interception by the breakwater up to the maximum rate of transport. As the wave energy is dissipated on the breakwater, sand is deposited on the shore in a convex seaward formation. This then acts as a natural groin which further impounds the littoral drift. The effects of an offshore breakwater are shown on Figure 3.

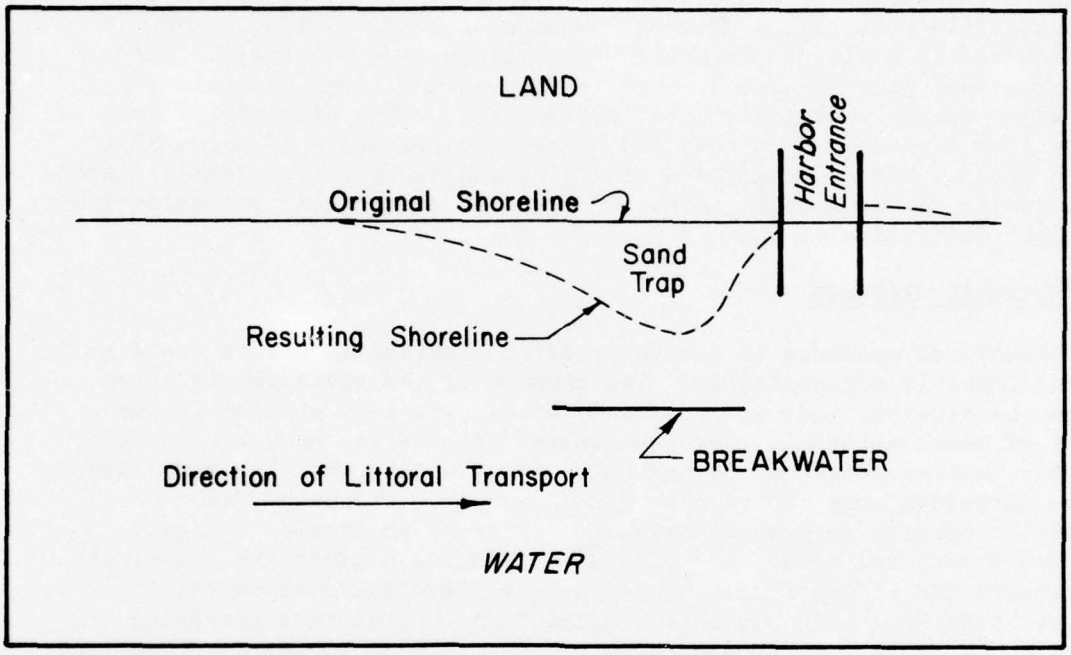


FIGURE 3 - EFFECT OF OFFSHORE BREAKWATER

Where little or no protective beach exists, upland areas and improvements can be protected by a seawall or revetment. A seawall is a structure that retains the material behind it, whereas revetment is essentially a pavement structure laid on the natural slope of the land. Both structures allow the waves to expend their destructive energies without causing additional erosion. Neither of these structures interfere with the littoral currents.

Some economic considerations affecting the selection of shore protection structures warrant discussion. When large quantities of sand are available within an economically practical distance from the eroding beach, replenishment is a desirable structural measure. At present, sand deposits in up to 70 feet of water can be dredged economically. In 1968, an offshore borrow area was used as a source for 1,400,000 cubic yards of sand to replenish a beach in the South Coastal subregion. The material was dredged from a depth of 40 to 70 feet, and was pumped a distance of one-half mile to the project beach through a pipeline.

In general, the cost per cubic yard of beach material varies inversely with the quantity and directly with the distance and the difficulty of the work. Future economic limits will probably change as new technology for offshore dredging develops and as the need for beach material increases.

When sand is not available nearby, more reliance must be placed on stabilization through construction of groins. In California, groins are most generally constructed of rock, because rock is relatively cheap, durable, and is easier to work with than alternative materials. For these reasons, rock is also used for most revetment; and seawalls are, generally, rather uncommonly used in California. The size of the rock varies from 5 pounds to 25 tons and has an average price of about $9 a ton in place. The economic life of groins and revetment is usually taken as 50 years, although rock groins, if properly constructed and maintained will last indefinitely.

NONSTRUCTURAL MEASURES

Structural measures to control erosion wherever it occurs would be neither feasible nor desirable. The scenery of the shoreline is often created by erosion, and, as previously discussed, this erosion is one source of beach material. Erosion-control structures, however are not the only measures that may be taken to mitigate damages. The open lands in the shoreline zone may be controlled through a regulatory and management program to prevent developments prone to erosion damage. Such non-structural measures would reduce erosion damages and contribute to preservation of the scenic beauty of the shoreline environment. Various bills have been presented to the State Legislature proposing formation of State and regional commissions, similar to the San Francisco Bay Conservation and Development Commission, to regulate development of the coastline. It is to be anticipated that necessary regulatory measures will be enacted to meet shoreline needs.

REGIONAL SUMMARY

Description of the Region

PHYSICAL CHARACTERISTICS

The coastal portion of the California Region is within four subregions--the North Coastal, San Francisco Bay, Central Coastal and South Coastal. Map 1 shows the location of these subregions. The shoreline of the Region is about 1,746 miles long, comprised of 1,073 miles of mainland coastal shoreline, 276 miles of shoreline within San Francisco Bay and 397 miles of shoreline in the eight Channel Islands.

The coastal portion of the Region is predominantly mountainous, except in the South Coastal subregion, a part of which has a fairly broad coastal plain. San Francisco Bay, through which the Sacramento-San Joaquin river system drains to the ocean, lies about 320 miles south of the California-Oregon border. Eight islands lie offshore south of Point Conception. There are also a few rocky islets; the largest are the Farallons, off San Francisco.

The major drainages in the Region generally lie between southeast-northwest trending coastal mountain ranges. Major streams north of San Francisco Bay are the Smith, Klamath, Mad, Eel and Russian rivers. Between San Francisco Bay and Point Conception, major streams are the Salinas, Santa Maria and Santa Ynez. The coastal valleys of these streams are as much as 15 miles wide. South of Point Conception the streams are all intermittent. Major drainages are the Santa Clara, Los Angeles, San Gabriel, Santa Ana, San Luis Rey and San Diego rivers.

The continental shelf is narrow; throughout the region 600-foot depths are within 30 miles of the shoreline. The shelf is cut by deep and pronounced submarine canyons in many places.

CLIMATE AND EXPOSURE

The climate of the coastal areas of the Region is very temperate, with moderate summers and mild winters. Rainfall occurs during the winter months, and temperatures exhibit neither pronounced diurnal nor seasonal variations. The climate in the south part of the Region is warmer and drier than in the north. Average coastal climates and normal sea temperatures for each subregion are summarized in the following table.

Item	Subregion			
	South Coastal	Central Coastal[1/]	San Francisco Bay	North Coastal
Normal annual rainfall (inches)	14"	21"	19"	38"
Normal air temperature:				
Minimum	50°F	50°F	48°F	47°F
Maximum	78°F	68°F	65°F	58°F
Normal cloud cover (% of year)				
Clear	42%	47%	45%	22%
Partly cloudy	33%	30%	28%	27%
Cloudy	25%	23%	27%	51%
Normal wind velocity (knots)	5.7 k	8.6 k	9.0 k	5.9 k
Normal sea temperatures:				
Minimum	56°F	54°F	51°F	49°F
Maximum	68°F	60°F	60°F[2/]	57°F
Number of months with sea temperature 60°F or more	7	2	1[2/]	0

1/ Climate and sea temperatures in that part of the subregion downcoast from Point Conception are about the same as the South Coastal subregion.

2/ Data are for ocean temperatures. Within San Francisco Bay, normal maximum water temperature is 69°F.; water temperature is 60°F. or more for 7 months. A water temperature of 60°F or higher is accepted as suitable for swimming.

Both advection and radiation fogs are common to the entire coast; the advection type is more frequent and extensive. Notably foggy areas are Humboldt Bay, Point Arena, Point Reyes, Estero Bay and Point Arguello. Surface fogs are not common south of Point Arguello, since warm water eddies lie between the coast and the cool California current.

Tides along the Region's coast are of the type known as mixed. Mixed tides usually have two high waters and two low waters of each tidal day, and exhibit large inequalities in either the high or low water heights. The average diurnal range (the difference in height between mean higher high water and mean lower low water) varies from 5.3 feet in the southern part of the region to 6.9 feet in the northern part. Mean tide level (a plane midway between mean low water and mean high water) varies from 2.8 feet above mean lower low water in the southern part of the region to 3.7 feet above mean lower low water in the northern part.

The various waves that have been observed to reach the shore of the California Region, exclusive of tides and surge, can be classified into three general categories--wind waves, swell, and tsunamis. Wind waves are those that are growing in height under the influence of local winds. They have short periods, 4 to 8 seconds, and are due directly to the winds that are blowing at the time the waves arrive. Except during the infrequent occurrence of strong gales along the Pacific Coast, wind waves are low in height, and have a relatively negligible effect on the shoreline. From the Oregon-California boundary to Point Conception, gales occur about 2 percent of the year. The coastal waters south from Point Conception have gales less than one percent of the year.

The waves that have paramount influence on the local shore regimen are those that come under the classification of "swell." The collective term "swell" denotes the longer-period waves generated by distant ocean storms. During the winter and spring, severe waves may be generated by extra-tropical cyclones that originate near Japan and proceed eastward across the Pacific to the Gulf of Alaska. Waves generated by these storms reach most of California, but usually show a steady decrease in energy intensity southward along the coast. Southern California experiences its most severe wave conditions from extra-tropical cyclones when storms develop between Hawaii and the Pacific Coast. During the summer and early fall, tropical cyclones that occur off of the western coast of Mexico and waves generated by extra-tropical cyclones in the South Pacific Ocean may reach the shoreline of the South Coastal subregion. Each of these southerly wave episodes lasts for several days.

The final type of waves that occasionally reach the Region's shoreline are known as tsunamis, and are caused by a sudden large

displacement of sea bottom or shore. Tsunamis have caused damage along the Region's shoreline; this damage has been particularly pronounced at Crescent City, in the North Coastal subregion.

Along the entire coast of the Region, waves approaching shore are influenced considerably by refraction over the continental shelf. This refraction turns the wave front so that it tends to approach parallel to shore. This turning action is often not complete, and waves approach in an oblique-to-shore angle.

When swell from the open ocean approaches the coast south of Point Conception, portions of each wave crest are absorbed by the islands offshore, and those wave elements that pass close to the islands have their direction altered by refraction over the insular shelves.

POPULATION DISTRIBUTION

The four coastal subregions had a population of about 14,885,000 in 1965, which was 82 percent of the total population of the California Region, estimated at 18,106,000. The most heavily populated subregions were the San Francisco Bay and South Coastal subregions, with 1965 populations of 4,061,000 and 9,910,000 respectively; 77 percent of the Region's people lived in these two subregions.

Most of the Region's swimming beaches are located in the South Coastal subregion and in the southern part of the Central Coastal subregion. In 1965, over 50 percent of the region's population lived in coastal areas within day-use range of these swimming beaches. The region's shoreline is accessible to the population of inland subregions for weekend or vacation use. Additionally, the region's shoreline has, for decades, been an important destination for tourists from other areas of the nation.

ECONOMY

The fact that 82 percent of the Region's people live in the coastal zone is reflected by the economy of that zone. Every economic sector is represented; the economy of the Region is essentially the economy of its coastal zone. The subregional chapters summarize briefly the economy of each of the four coastal subregions; the economy is discussed in more depth in Appendix IV, Economic Base and Projections.

TRANSPORTATION

The Region has a well-developed multimodal transportation system. A north-south interstate highway (U. S. Highway No. 101) and a state highway (State Highway No. 1) parallel the shoreline throughout the entire Region. Improved roads provide access to most of the shoreline.

South of San Francisco Bay, rail service is available to most of the coastal area. The region has adequate bus service; and numerous major and minor air terminals.

Existing Conditions in the Shoreline Zone

GENERAL

The coastline of the California Region is gently convex, and is oriented on an azimuth of about 340°. The most westerly point is Cape Mendocino, about 200 miles north of the entrance to San Francisco Bay. The general trend of the coast turns sharply to an azimuth of about 290° at Point Conception, about 250 miles south of the entrance to San Francisco Bay.

About 35 percent of the 1,073-mile-long mainland coastal shoreline is comprised of rocky headlands. The remaining 65 percent is beach; comprised of 9 percent rocky beach and 56 percent sandy beach. The 397-mile-long shoreline of the Channel Islands is primarily rocky. The 276-mile-long perimeter of San Francisco Bay is a complex intermix, including considerable marshy shoreline. The general characteristics of the ocean shoreline are shown on Map 2.

The prevailing direction of net littoral transport is generally downcoast, from Oregon to Mexico. Existing data indicate that littoral drift quantities range from 60,000 to 1,000,000 cubic yards per annum. In localized areas, net littoral transport is upcoast.

DESCRIPTION OF SHORELINE

A detailed description of the shoreline zone is contained in the subregion chapters.

The physical character of the shoreline is described, including the nature of the foreshore, backshore, and upland areas. These terms are illustrated in Figure 4.

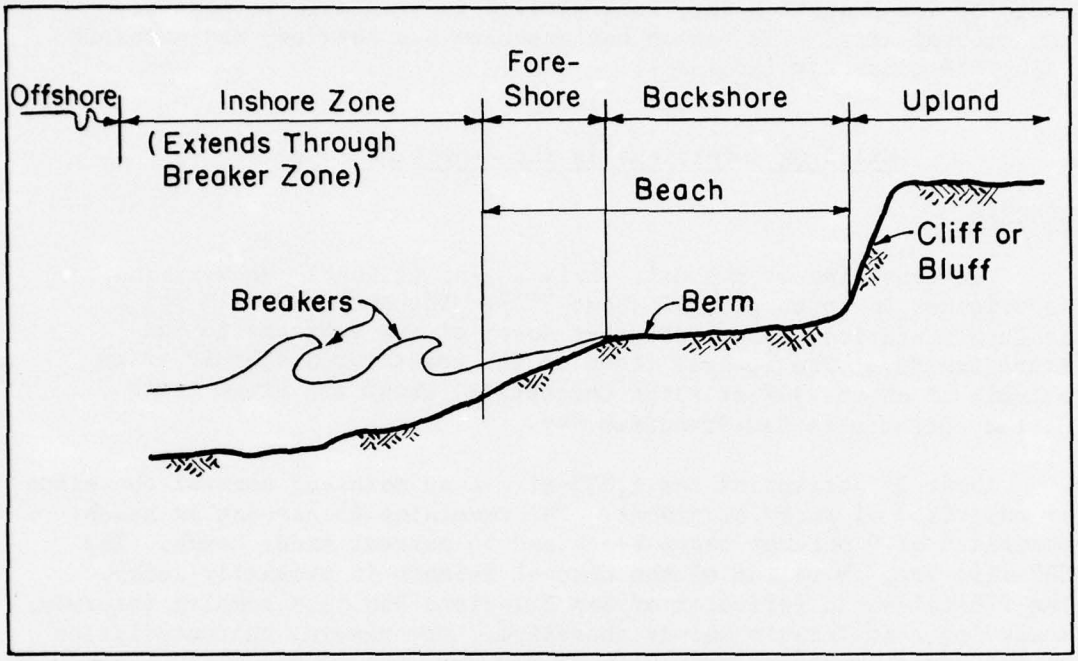


FIGURE 4 – SHORELINE PROFILE, RELATED TERMS

The coastal shoreline distances referred to in the subregional descriptions and used elsewhere in this appendix were obtained from drawings prepared by the California Department of Parks and Recreation, which cover the mainland ocean shoreline. A measurement system was established on these drawings, which are at a scale of 1 inch equals 1/2 mile.

The subregional chapters include descriptions of the shoreline topography, access, recreational facilities and uses, the relative importance of fish, widlife and ecologic resources, structural encroachments in the shoreline zone, and shoreline erosion characteristics and problems.

LAND USE

Land use in the mainland shoreline zone in 1965 was classified into six major categories: urban, agricultural, military, public reserves, harbors and other. Data were obtained from the U. S. Coast and Geodetic Survey quadrangle maps and from 1965 aerial photography. Where the shoreline zone is in part comprised of beach, land use classifications pertain to the part of the shoreline zone inshore from the beach. Urban use includes residential, commercial and industrial uses. Agricultural use includes both cultivated lands and grazing lands. The shoreline within military reservations was classified as military land use. Some military use of shoreline not within military reservations was also included in this category. The public reserve category includes parks, national forests, wildlife reserves and U. S. Coast Guard reservations. Harbors comprise both commercial and recreational navigation facilities; all of the shoreline within harbor protective structures or used for harbor facilities was included in this category. All remaining land uses were categorized as "other." This category includes unused or sparsely developed lands, lagoons, marshes and river mouths.

Of the 1,349-mile-long mainland shoreline (including 276 miles within San Francisco Bay), 21 percent of the shoreline zone is in urban land use, 20 percent is agricultural, 8 percent is military, 19 percent is public reserve, 3 percent is harbor and the remaining 29 percent is in other uses.

Land use in the shoreline zone in 1965 is summarized in the following table, by subregions, and is shown on Map 3.

Subregion	Land use, in shoreline miles						
	Urban	Agri-culture	Military	Public Reserve	Harbors	Other	Total
North Coastal	14.3	87.0	0	90.6	1.0	138.9	331.8
San Francisco Bay:							
Coastal	15.9	24.4	6.3	78.1	0.6	26.5	151.8
Bay	52.0	25.7	25.4	4.9	25.1	142.9	276.0
Central Coastal	65.9	122.2	41.3	55.4	1.7	69.6	356.1
South Coastal	134.5	9.2	36.3	23.1	10.2	19.7	233.0
Total	282.6	268.5	109.3	252.1	38.6	397.6	1,348.7
Islands	1.0	153.0	138.0	20.0	0	85.0	397.0

OWNERSHIP

Ownership of the shoreline zone was classified as State, Federal, local, and private; "local" includes all other public ownerships. Data were obtained from the State Department of Parks and Recreation drawings, and from available maps and studies of the perimeter of San Francisco Bay. Data from the State drawings, which were prepared in 1969, were modified to reflect base year conditions. Ownership of the Channel Islands was obtained from a National Park Service publication titled "Channel Islands" (G.P.O. 1963). Of the 1,349-mile long mainland shoreline (including 276 miles within San Francisco Bay), about 33 percent is publicly owned. This 33 percent is comprised of 11 percent Federal, 15 percent State, and 7 percent local ownership. Ownership of the shoreline in 1965 is summarized in the following table, by subregions, and is shown on Map 3.

Subregion	Land ownership, in shoreline miles					
	Public				Private	Total
	Federal	State	Local	Subtotal		
North Coastal	12.3	39.5	6.4	58.2	273.6	331.8
San Francisco Bay:						
Coastal	24.6	30.9	9.3	64.8	87.0	151.8
Bay	26.5	16.1	31.9	74.5	201.5	276.0
Central Coastal	51.2	57.0	14.2	122.4	233.7	356.1
South Coastal	34.8	58.8	37.1	130.7	102.3	233.0
Total	149.4	202.3	98.9	450.6	898.1	1,348.7
Islands	158.0	0	1.0	159.0	238.0	397.0

RECREATIONAL SHORELINE

The public recreational shoreline available in 1965 comprised swimming beach, non-swimming beach, and scenic shoreline. These terms are defined in the introduction to this appendix. In 1965, about 25 percent of the mainland coastal shoreline was available; of this 25 percent, 10 percent was swimming beach, 8 percent was non-swimming beach and 7 percent was scenic shoreline. Available public recreational shoreline is summarized in the following table, by subregions, and is shown on Map 4.

Subregion	Recreational and Scenic Shoreline, in miles		
	Swimming Beach	Non-swimming Beach	Scenic Shoreline
North Coastal	0	14.0	32.0
San Francisco Bay:			
Coastal	0	49.0	31.0
Bay	4.0	0	0
Central Coastal	20.0	26.0	6.0
South Coastal	83.0	1.3	7.0
Total, mainland	107.0	90.3	76.0
Islands	0	0	20.0

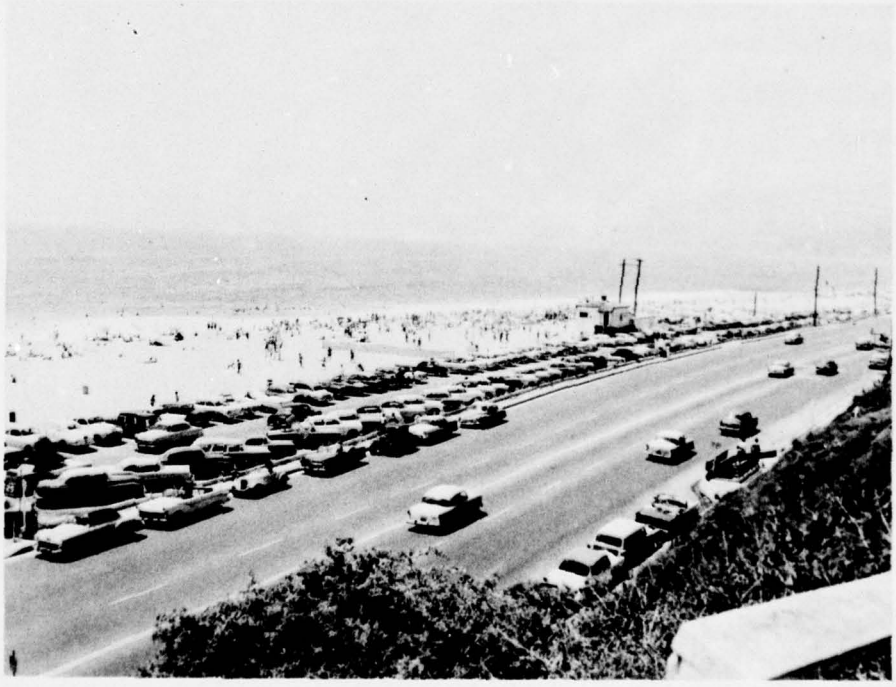
Shoreline recreation includes swimming, sunbathing, surfing, SCUBA and free diving, fishing and shellfishing, picnicking, camping, tidepool exploration, wildlife study, driftwood and rock collecting, and walking or driving in the coastal environment. The average shoreline visitor will usually participate in more than one activity during each visit. By far, the greatest number of visitors are attracted to the shoreline by the desire for swimming and sunbathing. The recreation afforded by public shoreline in 1965 is estimated at about 70 million recreation days. Almost 80 percent of this recreation was afforded by the swimming beaches in the South and Central Coastal subregions. Recreational navigation along the Region's shoreline is discussed in Appendix XVII: Navigation. General recreation associated with the shoreline is also discussed in Appendix XII: Recreation.

EROSION CHARACTERISTICS

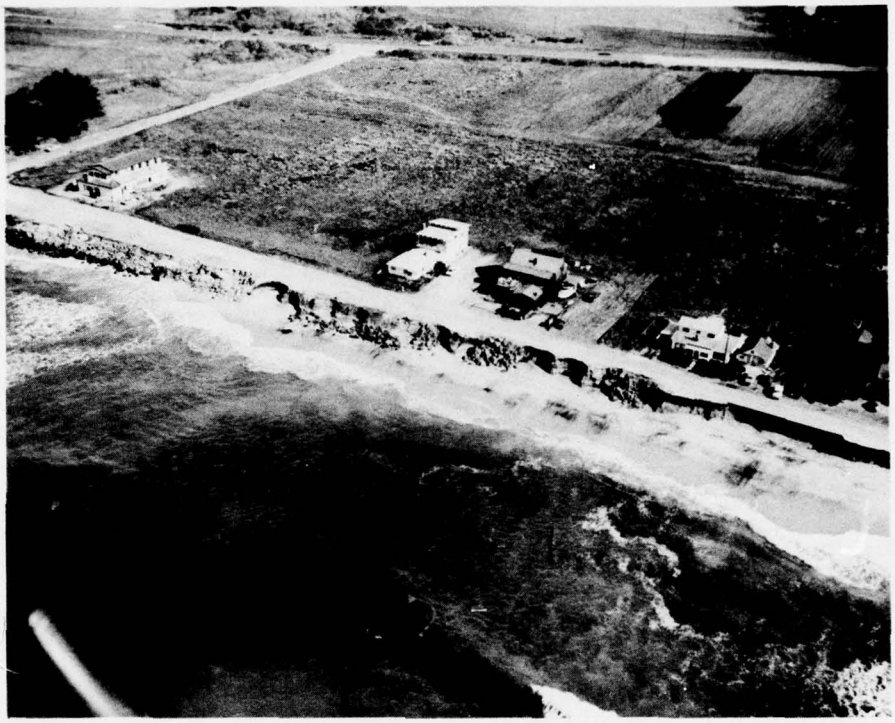
Geologically speaking, the entire shoreline is eroding to some degree. However, for the purpose of this report, erosion characteristics have been classified into three categories--critical, non-critical, and non-eroding. These categories are defined in the introduction.

The erosion characteristics of the Region's shoreline were estimated from historic trends, data available from existing reports and studies, and information furnished by government agencies. The character of shoreline formations, wave energies, littoral transport conditions, and existing structures in the active erosive zone

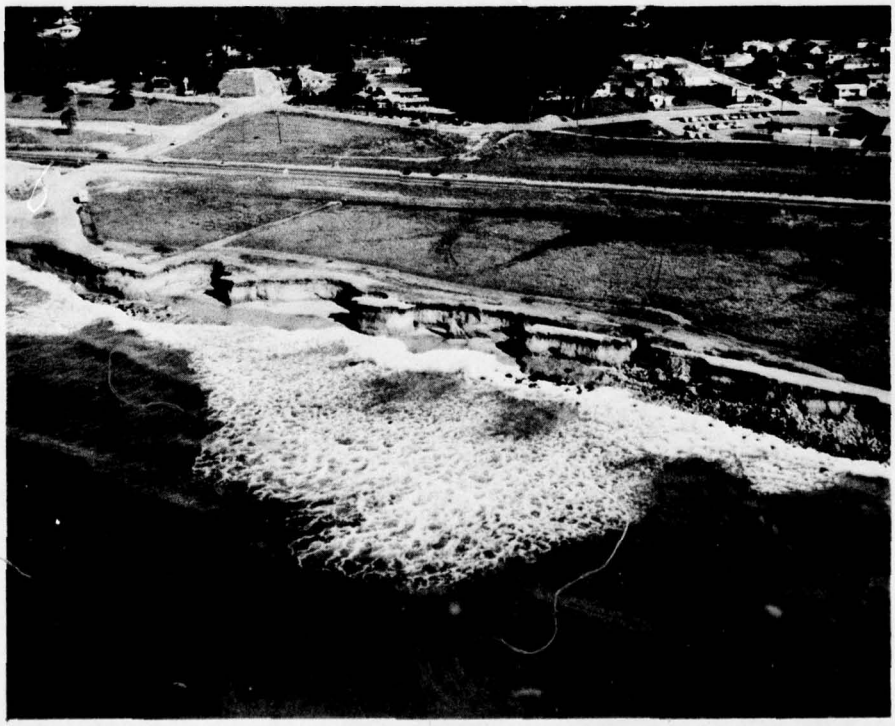
This photograph was taken at Stinson Beach in the San Francisco Bay subregion. The ocean water is cold and swimming is not very popular, but the beach is crowded with sunbathers on a warm day.
(State of Calif. Dept. of Parks and Recreation photo)



Will Rogers State Beach, in the South Coastal subregion, is located close to a large metropolitan area and is heavily used for swimming and sunbathing.
(State of Calif. Dept. of Parks and Recreation photo)



At El Granada Beach, in the San Francisco Bay subregion, critical erosion has caused extensive damage to private and public property. (Corps of Engineers photos)



These residences in Pacifica (San Francisco Bay Subregion) are endangered by serious erosion.
(Corps of Engineers photo)

This slide damage occurred in the Point Fermin area of Palos Verdes Peninsula, in the South Coastal subregion. The head of the slide is indicated by the dashed line. (Photo by the City of Los Angeles, Department of Building and Safety)

were considered. Information on current status of critically eroding shoreline and protective measures is included in the subregional sections of this appendix. About 84 percent of the coastal mainland shoreline is eroding; 26 percent of the shoreline is eroding at a critical rate. This critical erosion threatens public and private facilities, including recreational swimming beaches; critical erosion is particularly significant south of Point Conception. The 16 percent of the shoreline that is not eroding is comprised of river and channel mouths, resistant rock, or shoreline protected by structures. Erosion characteristics were not estimated for the Channel Islands; none of the islands' shoreline is critically eroding. Erosion characteristics along the mainland shoreline are summarized in the following tabulation.

Subregion	Erosion Characteristics, in miles			
	Critical	Non-critical	Non-eroding	Total
North Coastal	15.5	238.5	77.8	331.8
San Francisco Bay:				
Coastal	9.6	116.5	25.7	151.8
Bay interior	3.6	242.9	29.5	276.0
Central Coastal	89.7	220.4	46.0	356.1
South Coastal	163.1	43.0	26.9	233.0
Total, mainland	281.5	861.3	205.9	1,348.7

PROTECTIVE AND MITIGATIVE EFFORTS

General

The term "protection," as used in this report, refers to both structural and non-structural measures for the reduction of damages caused by shoreline erosion. Structural measures include such works as stabilization and beach fill, seawalls and revetments, and periodic replenishment of existing beaches. Non-structural measures refer to the zoning and regulating of shoreline uses. The term "development" refers to the creation of new beaches and acquisition of scenic shoreline for public recreational use.

Federal Projects

The 1930 River and Harbor Act authorized the Corps of Engineers to investigate shore processes and beach erosion problems in cooperation with the States. Later authorizations permitted the Federal Government to assume up to 70 percent of the construction cost for protecting certain publicly-owned shoreline parks or conservation areas, and to make limited contribution toward the cost of protecting privately-owned shoreline where public benefit results. Non-Federal interests assume all remaining costs and meet certain other requirements of local cooperation. Investigations of beach erosion and related problems, which may be carried out entirely at Federal expense, must be authorized by River and Harbor Acts, or by resolutions of the Senate or House Committee on Public Works. Except for construction of certain small improvements, which may be authorized by the Chief of Engineers, Federal participation in beach-erosion control and shore-protection projects must be specifically authorized by the Congress.

Five general categories of shore, based on ownership and use, and incidence and type of benefits, must be considered in determining Federal aid toward the cost of shore restoration and protection. These categories, and the levels of Federal aid applicable thereto, are listed in the following table.

This revetment is a part of the Federal shore-protection work constructed by the Corps of Engineers at Santa Cruz, in the Central Coastal subregion.

(Corps of Engineers photo)

Private property owners have also revetted the shoreline in front of their homes in the Santa Cruz area.

(Corps of Engineers photo)

Shore Category	Maximum level of Federal aid	
	Construction	Maintenance
Federally owned	100%	100%
Publicly owned, non-Federal parks and conservation areas	70%*	None
Publicly owned, non-Federal other than parks and conservation areas	50%*	None
Privately owned, protection will result in public benefits**	50% multiplied by the ratio of public benefits to total benefits	None
Privately owned, protection will not result in public benefits susceptible of evaluation	None	None

* Cost-sharing percentages do not apply to purchase of lands, easements and rights-of-way.

** Privately owned shores under public control, as through a sufficiently long-term lease assuring realization of public benefits throughout the economic life of the project, may be treated as publicly-owned non-Federal (other than parks and conservation areas) shores in determining Federal aid.

Protective work can also be performed entirely at Federal expense, regardless of Shore Category, where erosion is attributable to Federal navigation works.

By 1965, Federal beach-erosion control and shore protection works affecting about 26 miles of shoreline had been constructed in the Region. With the exception of 1 mile in the Central Coastal subregion, this work was entirely within the South Coastal subregion. A detailed listing of completed Federal projects and Federal projects under construction is contained in the subregional chapters.

The Division of Beaches and Parks, Department of Natural Resources, State of California, made formal application in July 1946 for a continuing cooperative Federal-State study of the problems of beach erosion and shore protection along the Pacific coast of the State of California. The first phase of the cooperative studies, covering the reach of shoreline from Cape San Martin to the Mexican Border, has been completed.

In 1962, Congress authorized the Corps of Engineers to study shore-erosion problems entirely at Federal expense for shore areas that are legally eligible for Federal participation in construction. Investigations are authorized for the coast of southern California;

all of Santa Barbara and San Francisco counties; Los Angeles County from Point Mugu to Los Angeles Harbor; Imperial Beach in San Diego County; and Daly City, El Granada, Bolinas, and Pacifica, all in the San Francisco Bay subregion.

Non-Federal and Private Work

Considerable beach protection work within the Region has been done by various non-Federal agencies, including state, county and city agencies. This work consists of groins, placement of beach fill, revetment, and seawalls. Private work in the Region has consisted of groins and rubble placed to protect private properties; little of this private work is of a permanent nature. The non-Federal and private work is discussed in the subregional chapters.

Non-Structural Measures

Federal, State and local agencies have the authority to acquire shoreline for public recreational purposes or for preservation of natural resources. The extent of this acquisition has been previously discussed under "Ownership." State and local agencies have also developed general plans for the entire coastal area; in some areas shoreline master plans have also been developed. These non-structural measures are discussed in the subregional chapters.

SHORELINE EROSION DAMAGES, PRESENT CONDITIONS

Available historic data concerning shoreline erosion damages were utilized as a basis wherever possible. Where data were not available, the shoreline recession rate was estimated and the probable loss of property was evaluated.

The estimated average annual shoreline erosion damages, under present conditions, for the Region's shoreline are shown in the following tabulation.

Subregion	Average annual shoreline erosion damage, in $1,000 (1965 prices)
North Coastal	1,070
San Francisco Bay	1,400
Central Coastal	2,210
South Coastal	5,210
TOTAL REGION	9,890

Future Needs inthe Shoreline Zone

GENERAL

Future needs are evaluated in terms of reducing shoreline erosion damage and meeting the needs for recreational shoreline, including conservation of scenic shoreline. The bases for estimating these future needs are discussed in the following paragraphs.

BASES FOR EVALUATING FUTURE SHORELINE EROSION DAMAGES

The average annual damages to public and private property in the shoreline zone for the base year 1965 were projected to the years 1980, 2000, and 2020. It was assumed that future average annual damages would bear a direct relationship to the changing value of damageable items within the shoreline zone. The basic parameters that were used in evaluating the anticipated changing value in the shoreline zone were:

(1) The expected changes in yields per acre were used to appraise the future changes in agricultural values. Future uses of the shoreline zone for cropland and pasture in the various target years were projected by an examination of historical trends and an evaluation of foreseeable future developments. Improvements in agricultural production technology (crop yields) will result in a corresponding increase in the per acre value of the agricultural acreage within the shoreline zone. The increased use of commercial fertilizer, improved varieties, the expanded use of acceptable and effective pesticides and a greater application of advanced animal husbandry techniques were the major factors considered in projecting the growth in the yield indices. By applying the projected yield indices (in relation to the estimated future use patterns) to the projected agricultural land in the shoreline zone, the future agricultural values were computed.

(2) In projecting the future trends in the value of damageable residential and commercial property in the shoreline zone, projected damages in real per capita income and population density were used as the relevant indicators. The same indices of change were assumed to apply for both the residential and commercial values because of their interrelationships and a lack of data to indicate any significant difference in their frequency of change on a subregional basis. The percentage changes in real per capita income and population density (although giving a good indication of the total changing value of residential and commercial property in the subregion) were adjusted downward. This downward adjustment was based on the assumption that present population densities in the shoreline zone are

greater than densities in the subregion as a whole, and therefore relative density in the shoreline zone would increase at a lower rate. In making the above projections, data related to the future regional trends in real per capita personal income, obtained from the Office of Business Economics of the Department of Commerce, and future Base Plan regional population characteristics, as outlined in the Economics Appendix, were utilized.

(3) The projected changes in public facility values in the shoreline zone were assumed to be a function of the changes in area population and Base Plan projected increases in real per capita personal income for the different target years. Because a more intense use of the existing public facilities can be expected to occur in the future as area population expands, the percentage changes in public facility values were made to lag the expected future changes in value for the residential and commercial property in the shoreline zone.

Development factors incorporating the basis parameters outlined above were derived for the various segments of the shoreline zone and then applied to available data on average annual shoreline erosion and tsunami damages (1965) to develop estimates of projected average annual shoreline erosion and tsunami damages for the target years 1980, 2000 and 2020.

BASES FOR EVALUATING SHORELINE RECREATION NEEDS

Recreational activities at the shoreline include boating, swimming, surfing, SCUBA and free diving, sunbathing, fishing and shellfishing, picnicking, camping, tidepool exploration, driftwood collecting, walking and enjoying the coastal atmosphere. With the exception of the boater, the average shoreline visitor will usually participate in more than one activity during each visit. The greatest number of visitors are attracted to the shoreline by the desire for swimming and sunbathing. The criteria used to estimate the amount of shoreline required for these recreational activities are discussed in the next paragraph.

The State of California, in considering recreational shoreline needs, has used a criterion of 25 front feet of shoreline per 1,000 population. The Corps of Engineers criteria for recreational swimming beach assumes that (1) each peak-hour visitor would require up to 100 square feet of dry sand; (2) 3 to 6 percent of the tributary area population would attend the beach on a peak day; and (3) the peak-hour beach attendance would be one-half of the peak-day attendance. Applying both criteria, a beach frontage of 25 feet with a berm width of about 100 feet would provide the required sand area.

The two criterion are considered generally compatible. This study has used 25 front feet per 1,000 population to estimate both swimming beach and non-swimming beach requirements.

Swimming beaches are particularly subject to intensive use. In addition to the dry sand area, an upland or back-beach area is required for parking and other support facilities. For heavily-used urban swimming beaches where most visitors arrive by automobile, as is normal in California, a back-beach area 265 feet wide is required for parking. An additional area 100 feet wide is desirable for buffer planting, picnic areas, utilities and other support facilities. From the standpoint of convenience and safety, it is desirable that the parking and service areas be immediately adjacent to the swimming beach and seaward of the coastal access highways. In some areas, the coastal highway is so close to the shoreline that sufficient back-up area cannot be provided adjacent to the beach. In these cases, upland areas must be developed and safe pedestrian crossings provided for the public.

Future requirements for recreational beach shoreline were estimated by applying 25 front feet of shoreline per 1,000 population to Base Plan population projections in each time frame. Needs were determined in miles of beach shoreline; ease of access or adequacy of parking were not evaluated. The recreational needs for inland areas of the Region were included, and were assigned to appropriate coastal subregions. Needs were further identified as swimming beach or non-swimming beach needs, depending upon the physical characteristics of the shoreline and prevailing water temperatures in each subregion.

Recreation provided by scenic shoreline is primarily derived from tourism. The scenic shoreline of the California Region serves the recreational needs of the region's population and also provides considerable recreation for visitors from other parts of the nation. Future requirements for scenic shoreline were based on meeting these recreational needs, and on the need to conserve and preserve the unique scenic and scientific values of this resource. Shoreline identified as having scenic or scientific value by the National Park Service, the State of California Department of Parks and Recreation, or other agencies was used as a basis to determine the future availability of scenic shoreline to meet these needs.

SHORELINE EROSION DAMAGES, FUTURE CONDITIONS

The average annual shoreline erosion damages, under present and future conditions, for the Region are summarized, by subregions, in the following tabulation.

Subregion	Average annual shoreline erosion damages, in $1,000			
	1965	1980	2000	2020
North Coastal	1,070	1,520	3,070	6,000
San Francisco Bay	1,400	2,100	3,900	4,700
Central Coastal	2,210	3,490	7,280	14,170
South Coastal	5,210	8,600	15,440	24,020
REGION, TOTAL	9,890	15,710	29,690	48,890

SHORELINE RECREATION NEEDS

The projected needs for public recreational shoreline in the Region, including the mainland coast, the Channel Islands, and San Francisco Bay, are summarized, by subregions, in the following tabulation. Criteria for estimating needs for beaches and scenic shoreline are presented under a preceding heading "Bases for Evaluating Shoreline Recreation Needs."

Subregion	Cumulative Public Recreational Shoreline Needs, in Miles			
	1965	1980	2000	2020
North Coastal				
Swimming beach	0	0	0	0
Non-swimming beach	4	5	9	16
Scenic shoreline 1/	32	68	96	101
San Francisco Bay				
Swimming beach	4	7	11	16
Non-swimming beach	19	26	40	59
Scenic shoreline 1/	31	65	65	65
Central Coastal				
Swimming	6	7	13	23
Non-swimming beach	4	6	10	20
Scenic shoreline:				
Mainland	6	29	45	45
Island	0	153	188	188
South Coastal				
Swimming beach	48	67	95	121
Non-swimming beach	2	3	5	6
Scenic shoreline:				
Mainland	7	7	7	7
Island	20	20	20	20
REGION TOTAL				
Swimming beach	58	81	119	160
Non-swimming beach	29	40	64	101
Scenic shoreline:				
Mainland	76	169	213	218
Island	20	173	208	208

1/ Mainland

Means to Satisfy Future Needs in the Shoreline Zone

GENERAL

The shoreline program for the California Region includes structural and non-structural protective measures to reduce potential future damages, the development of additional swimming beach, the acquisition of shoreline for public recreational use, and the preservation of scenic shoreline.

STRUCTURAL MEASURES

In the development of the structural phase of the shoreline program, emphasis was placed on those urban and public recreational areas that are being threatened with critical erosion; and on the development of new sandy beaches.

The structural protective measures proposed would provide a high degree of protection and would prevent most erosion damage at their locations. Table 1, at the end of this chapter, summarizes the potential structural program for protection and development of the region's shoreline, by time frames.

NON-STRUCTURAL MEASURES

In the development of the non-structural phase of the shoreline protection program emphasis was placed on management of the shoreline zone to regulate construction of improvements subject to damage. Coefficients were developed to reflect the probable effectiveness of management program in preventing damage. It was assumed that the effectiveness of management or zoning would be reduced by several conditions: first, the erosion loss of land itself cannot be prevented except through structural measures; second, improvements that already existed in 1965 within the probable erosive zone would remain in jeopardy; third, uniform zoning and management procedures for the coastal zone had not been developed in 1970, and the political climate indicated that it could be several years before such procedures were developed; fourth, implementation of procedures that may be adopted is likely to require some time; and finally, subdivision or development plans that have been approved prior to establishment of uniform management procedures are unlikely to be retroactively abrogated.

Effectiveness coefficients were developed to reflect the aforestated conditions. These coefficients assumed that management could prevent 15 percent to 60 percent of future damages. The lower effectiveness coefficients were used in privately-owned area where there

were existing improvements within the probable erosive zone and where existing densities of improvement do not allow for much future increase in the number of improvements. In these areas, management would be relatively ineffective in preventing future damages to improvements. The higher effectiveness coefficients were used in areas where there were few existing improvements within the probable erosize zone and where public ownership would permit full implementation of management procedures. In these areas, management should be very effective in preventing future damages to improvements.

It was assumed that non-structural measures would be applied to the shoreline zone as follows:

(1) By the year 1980, all public land and 20 percent of the private land would be under a management program.

(2) By the year 2000, all newly-acquired public land and 50 percent of the previously unmanaged private land would be under a management program.

(3) By the year 2020, all newly-acquired public land and 70 percent of the previously unmanaged private land would be under a management program.

In areas where the estimated effectiveness coefficient was below 0.25, it was assumed that structural measures would be required.

ACQUISITION OF RECREATIONAL SHORELINE

The program provides for acquisition of swimming and non-swimming beaches and scenic shoreline. (See Table 3) Part of this acquisition would be through purchase by public agencies; part would be through permitting future public use of Federally-owned non-recreational shoreline. The program proposes acquisition and/or development of 51 miles of swimming beach; and acquisition of about 23 miles of non-swimming beach. Additional beach areas would also be created incidental to the structural protection program. The program would also provide for acquisition of 330 miles of scenic shoreline; comprised of 142 miles of mainland shoreline and 188 miles of shoreline on the Channel Islands, which would have considerable recreation value. The primary source used in developing the recommended scenic shoreline program was the "Pacific Coast Recreation Area Survey", a report by the U.S. Department of the Interior, National Park Service, in 1959. Some shoreline identified in that report has been acquired in public ownership since 1959; some shoreline has lost its natural scenic or scientific value because of urban encroachment; and some shoreline, particularly in the South Coastal subregion, is being proposed in the shoreline program presented in this appendix as future swimming beach, rather than as scenic shoreline reserve.

Specific shoreline areas proposed for preservation are listed in the following tabulation, by subregion. Their locations are shown on the maps following the subregional chapters.

Scenic Shoreline Preservation, 1966-2020

North Coastal Subregion
- Pelican Bay Beach
- Pebble Beach
- Shell Beach
- Redwood National Park
- Gold Bluffs
- The Lagoons
- Elk Head
- Mad River Beach and Slough Area
- Humboldt Bay South Spit
- Ten Mile River Beach
- Caspar Point
- Mendocino City Area
- Little River-Mendocino Bay
- Manchester Beach-Point Arena
- Haven's Neck
- Salt Point

San Francisco Bay Subregion
- Point Reyes Peninsula
- Pigeon Point Area
- Franklin Point

Central Coastal Subregion
- Soberanes Point Area
- Little Sur
- False Sur
- Lime Kiln Creek
- Ragged Point
- San Simeon
- Point Buchon Area
- Santa Maria Dunes Area
- Santa Cruz Island
- Santa Rosa Island
- San Miguel Island

South Coastal Subregion
- (None)

Other shoreline in the Region has high scenic value. Some of this shoreline, particularly in the South Coastal subregion, is included in the shoreline program as proposed future public swimming beach. Other shoreline with scenic value, such as some of the shoreline of San Francisco Bay and the scenic area in Monterey Peninsula in the Central Coastal area, does not warrant preservation for its natural undisturbed qualities; but does warrant management aimed at enhancing public access and preventing aesthetic degradation. Formulation of guidelines for management of the coastal area to insure environmental quality is presently in progress, as part of the State Comprehensive Ocean Area Plan (COAP), which is in the process of preparation.

EFFECTIVENESS OF THE SHORELINE PROGRAM

As indicated in the tabulation on page 34, average annual shoreline erosion damages for the California Region will increase from about $9.9 million in 1965 to $15.7 million by 1980, $26.7 million by 2000, and $49.9 million by 2020, if no measures to prevent erosion damages are implemented after 1965. If the shoreline pro-

gram presented herein is fully implemented, the average annual residual shoreline erosion damages will decrease from about $9.9 million in 1965 to $7.3 million by 1980, $5.6 million by 2000, and $4.4 million by 2020, as shown in Table 2. The overall reduction of the potential average annual shoreline damages due to full implementation of the shoreline program amount to about $8.4 million by 1980, $21.1 million by 2000 and $44.5 million by 2020. Table 2 summarizes the effectiveness of the shoreline protection and development program in reducing shoreline erosion damages in the Region.

Publicly-owned recreational shoreline in the Region would increase from about 273 shoreline miles to 677 shoreline miles to meet the needs for swimming and non-swimming beach and conservation of scenic shoreline. Table 3 summarizes the extent of the shoreline available by types of shoreline and by time frames, if the program is implemented.

Implementation

BASES FOR COST ESTIMATES

Estimates of cost for the shoreline protection and development program in the California Region were based to a large extent on data from available reports and current studies, adjusted to reflect particular site conditions. Reconnaissance-scope estimates were made when existing data were not available. In general, unit costs were developed for each subregion for structural measures and applied to sites with similar characteristics. Estimated costs for acquisition of recreational shoreline were based upon prevailing land values for the particular area. The extent of each scenic shoreline site was determined by its scenic value and topography. Costs associated with non-structural measures to reduce potential future shoreline erosion damages were based on the estimated cost of studies needed to establish necessary guidelines for regulation of land use within the shoreline erosive zone.

ESTIMATED SHORELINE PROGRAM COSTS

The estimated installation costs for the shoreline protection and development program in the California Region, in 1965 dollars, amount to about $69.5 million for the 1966-1980 time frame, $62.9 million for the 1981-2000 time frame, and $54.3 million for the 2001-2020 time frame. These cost estimates do not include expenditures for access roads, or parking and sanitary facilities, which are included in Appendix XII: Recreation under the general categories of development and acquisition costs for recreational land Classes I and II. Cumulative annual maintenance cost estimates amount to $781,000, $1,841,000 and $2,687,000 for the respective time frames. Table 4 summarizes the estimated costs for the shoreline protection and development program for the California Region.

Conclusions

Under existing conditions, the coastal shoreline of the California Region is subjected to natural erosion. If measures are not taken to reduce property damage due to erosion, erosion damage will increase from about $10 million per annum in 1965 to about $50 million per annum in 2020. The structural and non-structural measures set forth in this appendix would reduce erosion damages from $50 million per annum to $4.4 million per annum by 2020.

In 1965, the need for swimming beach was about 60 miles and for non-swimming beach, about 30 miles. By 2020, the need for swimming beach will increase to about 160 miles and the need for non-swimming beach to about 100 miles. In 1965, 76 miles of mainland shoreline and 20 miles of Channel Islands shoreline were preserved in public ownership as natural scenic shoreline. An additional 142 miles of mainland shoreline and 188 miles of Channel Islands shoreline should be preserved as a future resource because of its unique scenic and ecologic character. Three-quarters of this preservation should be accomplished by 1980, and almost all of the balance by 2000 to prevent loss of the resource.

Substantial deficiencies of swimming and non-swimming beaches exist within counties of the Region, particularly near heavily populated urban areas. Under present conditions a regional shortage of about 18 miles of swimming beach in urban areas must be satisfied outside of the county of residence through longer travel by beach users. A corresponding shortage of about 5 miles of non-swimming beach exists. By the year 2020, with completion of the structural and non-structural measures set forth in this appendix, the within-county shortages would amount to 26 miles of swimming beach and 11 miles of non-swimming beach. Within subregions, except for the South Coastal subregion, within-county deficiencies are offset by facilities available in other parts of the subregion; however, in the South Coastal subregion, even with the suggested program, the overall shortages within the subregion will be 5 miles of swimming beach and about 4 miles of non-swimming beach by the year 2020.

Estimated costs for the structural and non-structural measures set forth in this appendix amount to approximately $187 million, of which about $80 million would be Federal and $107 million would be non-Federal. These costs include (1) protecting 95 miles of shoreline through construction of 54 miles of beach stabilization, 23 miles of seawall and 18 miles of beach replenishment; (2) construction of 30 miles of new beach; and (3) preservation of 330 miles of scenic shoreline.

Substantial reaches of the Region's shoreline that are privately owned and not available for public use are subject to critical erosion. This privately-owned shoreline is not eligible, under present policies, for Federal or State assistance to provide necessary improvements; accordingly, a very limited amount of such work has been done.

Some coastal streams discharge large volumes of sedimentary material into the littoral transport system. Water regulating measures may change the natural supply of material to the coast, influence the littoral transport equilibrium and affect shoreline erosion. The mining of sand within the littoral zone may also affect the supply of beach material; in at least one case, a correlation between sand mining and beach erosion has been noted. In addition, conservation of both onshore and offshore sand as a source for future beach replenishment material is needed.

Title to shoreline lands seaward of high tide is, for the most part, vested in the State of California. Private ownership of adjacent inshore lands may limit public access and preclude full development and use of public tidelands.

Recommendations

Incorporate into a master framework plan for the California Region the structural and non-structural measures set forth in this appendix to control critical erosion, protect and develop beaches and preserve scenic shoreline resources. These measures include: (1) 95 miles of structural protection, including 54 miles of beach stabilization, 23 miles of seawall and 18 miles of beach replenishment; (2) non-structural measures, including shoreline zoning and management; (3) construction of 30 miles of new beach; and (4) preservation of 330 miles of scenic shoreline.

The target dates for preservation of scenic shoreline set forth in this appendix should be met to prevent permanent loss of this irreplaceable national resource.

Studies should be made to determine if there should be increased Federal and State participation in the protection of privately-owned shoreline because of the extent of critical erosion that is occurring. Further, the design and construction of shore protection structures generally requires investigations beyond the expertise, and funding beyond the capability of private owners. Federal and State participation would require assurance of public access to, and use of, any beaches constructed as protective measures.

More extensive studies and data collection programs on the littoral transport phenomena and regimen should be initiated with a view to better understanding basic coastal phenomena. These studies should be directed toward quantifying the effects of coastal and landside development on the shoreline, and also should establish a basis for regulating mining of sand. These studies should include the detriments and benefits derived from mining sand; and inventory inshore and offshore sources of sand suitable for beach replenishment and development.

Sufficient rights-of-way should be acquired to assure public access to publicly-owned shoreline. Necessary investigations should be made to determine location and scope.

TABLE 1
CALIFORNIA REGION
Potential Projects, in Miles

Item	1966-1980	1981-2000	2001-2020	Program Total
North Coastal Subregion				
Beach Stabilization	1.0	1.0	1.0	3.0
Seawalls	2.0	1.0	2.0	5.0
Beach Replenishment	0	0	2.0	2.0
Beach Development	0	0	0	0
San Francisco Bay Subregion				
Beach Stabilization	4.0	3.0	2.0	9.0
Seawalls	1.0	2.0	2.0	5.0
Beach Replenishment	1.0	1.0	1.0	3.0
Beach Development	2.0	3.0	5.0	10.0
Central Coastal Subregion				
Beach Stabilization	6.0	6.0	1.0	13.0
Seawalls	3.0	3.6	2.0	8.6
Beach Replenishment	2.5	4.5	3.0	10.0
Beach Development	0	0	0	0
South Coastal Subregion				
Beach Stabilization	10.5	13.5	5.0	29.0
Seawalls	2.0	1.0	1.0	4.0
Beach Replenishment	1.0	2.0	0	3.0
Beach Development	0	5.0	15.0	20.0
REGION TOTAL				
Beach Stabilization	21.5	23.5	9.0	54.0
Seawalls	8.0	7.6	7.0	22.6
Beach Replenishment	4.5	7.5	6.0	18.0
Beach Development	2.0	8.0	20.0	30.0

TABLE 2
CALIFORNIA REGION
Estimated Average Annual Shoreline Erosion Damages and Damage Reduction through Shoreline Program, in $1,000 (1965 prices)

Item	North Coastal Subregion	San Francisco Bay Subregion	Central Coastal Subregion	South Coastal Subregion	Region Total
Average annual damage, 1965	1,070	1,400	2,210	5,210	9,890
Average annual damage by 1980 with no shoreline program	1,520	2,100	3,490	8,600	15,710
Reduction in damage with 1966 to 1980 shoreline program					
Structural measures	360	430	1,310	2,790	4,890
Non-structural measures	310	480	610	2,120	3,520
Program total	670	910	1,920	4,910	8,410
Residual annual damage in 1980	850	1,190	1,570	3,690	7,300
Average annual damage by 2000 with no shoreline program after 1980	1,520	1,570	2,960	6,620	12,670
Reduction in damage with 1981 to 2000 shoreline program					
Structural measures	310	510	1,290	1,730	3,840
Non-structural measures	440	90	430	2,240	3,200
Program total	750	600	1,720	3,970	7,040
Residual annual damage in 2000	770	970	1,240	2,650	5,630
Average annual damage by 2020 with no shoreline program after 2000	1,170	1,110	2,010	4,110	8,400
Reduction in damage with 2001 to 2020 shoreline program					
Structural measures	440	270	580	350	1,640
Non-structural measures	190	10	260	1,870	2,330
Program total	630	280	840	2,220	3,970
Residual annual damage in 2020	540	830	1,170	1,890	4,430
Estimated Annual damage in 2020 with no shoreline program after 1965	6,000	4,700	14,170	24,020	48,890
Total reduction in annual damage due to 1966 to 2020 shoreline program	5,460	3,870	13,000	22,130	44,460

TABLE 3
CALIFORNIA REGION
Estimated Recreational Shoreline Needed, and Recreational Shoreline Made Available by the Program, in Miles

Item	North Coastal Subregion			San Francisco Bay Subregion			Central Coastal Subregion			South Coastal Subregion			Region Total		
	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline
Available in 1965	0	14.0	32.0	4.0	49.0	31.0	19.9	25.9	6.0	83.0	1.3	27.0	106.9	90.2	96.0
Needed by 1980	0	5.0	-	7.0	26.0	-	7.2	5.8	-	67.0	3.0	-	81.2	39.8	-
Deficiency (-) or surplus (+)	0	+9.0	-	-3.0	+23.0	-	+12.7	+20.1	-	+16.0	-1.7	-	+25.7	+50.4	-
1966-1980 program supply	0	3.0	36.0	3.0	13.0	34.0	1.2	0	176.0	3.3	0.4	0	7.5	16.4	246.0
Available in 1980 with program	0	17.0	68.0	7.0	62.0	65.0	21.1	25.9	182.0	86.3	1.7	27.0	114.4	106.6	342.0
Needed by 2000	0	9.0	-	11.0	40.0	-	13.0	10.0	-	95.0	5.0	-	119.0	64.0	-
Deficiency (-) or surplus (+)	0	+8.0	-	-4.0	+22.0	-	+8.1	+15.9	-	-8.7	-3.3	-	-4.6	+42.6	-
1981-2000 program supply	0	1.0	28.0	4.0	2.0	0	1.8	0.1	51.0	14.7	0	0	20.5	3.1	79.0
Available in 2000 with program	0	18.0	96.0	11.0	64.0	65.0	22.9	26.0	233.0	101.0	1.7	27.0	134.9	109.7	421.0
Needed by 2020	0	16.0	-	16.0	59.0	-	23.0	20.0	-	121.0	6.0	-	160.0	101.0	-
Deficiency (-) or surplus (+)	0	+2.0	-	-5.0	+5.0	-	-0.1	+6.0	-	-20.0	-4.3	-	-25.1	+8.7	-
2001-2020 program supply	0	1.0	5.0	5.0	2.0	0	2.8	0.3	0	15.0	0	0	22.8	3.3	5.0
Available in 2020 with program	0	19.0	101.0	16.0	66.0	65.0	25.7	26.3	233.0	116.0	1.7	27.0	157.7	113.0	426.0
Needed by 2020	0	16.0	-	16.0	59.0	-	23.0	20.0	-	121.0	6.0	-	160.0	101.0	-
Deficiency (-) or surplus (+) at end of program	0	+3.0	-	0	+7.0	-	+2.7	+6.3	-	-5.0	-4.3	-	-2.3	+12.0	-

Note: Within-county deficiencies that are offset by surpluses within a subregion are shown in subregional Tables 3.

TABLE 4

CALIFORNIA REGION

Estimated Shoreline Program Costs, in $1,000 (1965 prices)

1966-1980 PROGRAM

Item	North Coastal Subregion	San Francisco Bay Subregion	Central Coastal Subregion	South Coastal Subregion	Region Total
STRUCTURAL MEASURES:					
Installation costs					
Federal	2,550	6,200	6,300	5,200	20,250
Non-Federal	2,050	7,500	6,300	5,200	21,050
Subtotal	4,600	13,700	12,600	10,400	41,300
Annual OM & R					
Federal	0	0	0	0	0
Non-Federal	60	250	220	104	634
Subtotal	60	250	220	104	634
NON-STRUCTURAL MEASURES:					
Installation costs					
Federal	4,000	8,400	7,300	0	19,700
Non-Federal	2,830	1,950	2,160	1,530	8,470
Subtotal	6,830	10,350	9,460	1,530	28,170
Annual OM & R					
Federal	43	80	0	0	123
Non-Federal	27	20	20	0	67
Subtotal	70	100	20	0	190
1966-1980 PROGRAM TOTAL					
Federal	6,550	14,600	13,600	5,200	39,950
Non-Federal	4,880	9,450	8,460	6,730	29,520
Total	11,430	24,050	22,060	11,930	69,470
Annual OM & R	130	350	240	104	824

Continued

TABLE 4--Continued

CALIFORNIA REGION

Estimated Shoreline Program Costs, in $1,000 (1965 prices)

1981-2000 PROGRAM

Item	North Coastal Subregion	San Francisco Bay Subregion	Central Coastal Subregion	South Coastal Subregion	Region Total
STRUCTURAL MEASURES:					
Installation costs					
Federal	2,200	7,650	8,680	6,500	25,030
Non-Federal	2,200	8,850	8,680	11,500	31,230
Subtotal	4,400	16,500	17,360	18,000	56,260
Annual OM & R					
Federal	0	0	0	0	0
Non-Federal	80	340	343	244	1,007
Subtotal	80	340	343	244	1,007
NON-STRUCTURAL MEASURES:					
Installation costs					
Federal	0	0	0	0	0
Non-Federal	5,330	150	960	230	6,670
Subtotal	5,330	150	960	230	6,670
Annual OM & R					
Federal	0	0	0	0	0
Non-Federal	50	0	3	0	53
Subtotal	50	0	3	0	53
1981-2000 PROGRAM TOTAL					
Federal	2,200	7,650	8,680	6,500	25,030
Non-Federal	7,530	9,000	9,640	11,730	37,900
Total	9,730	16,650	18,320	18,230	62,930
Annual OM & R	130	340	346	244	1,060

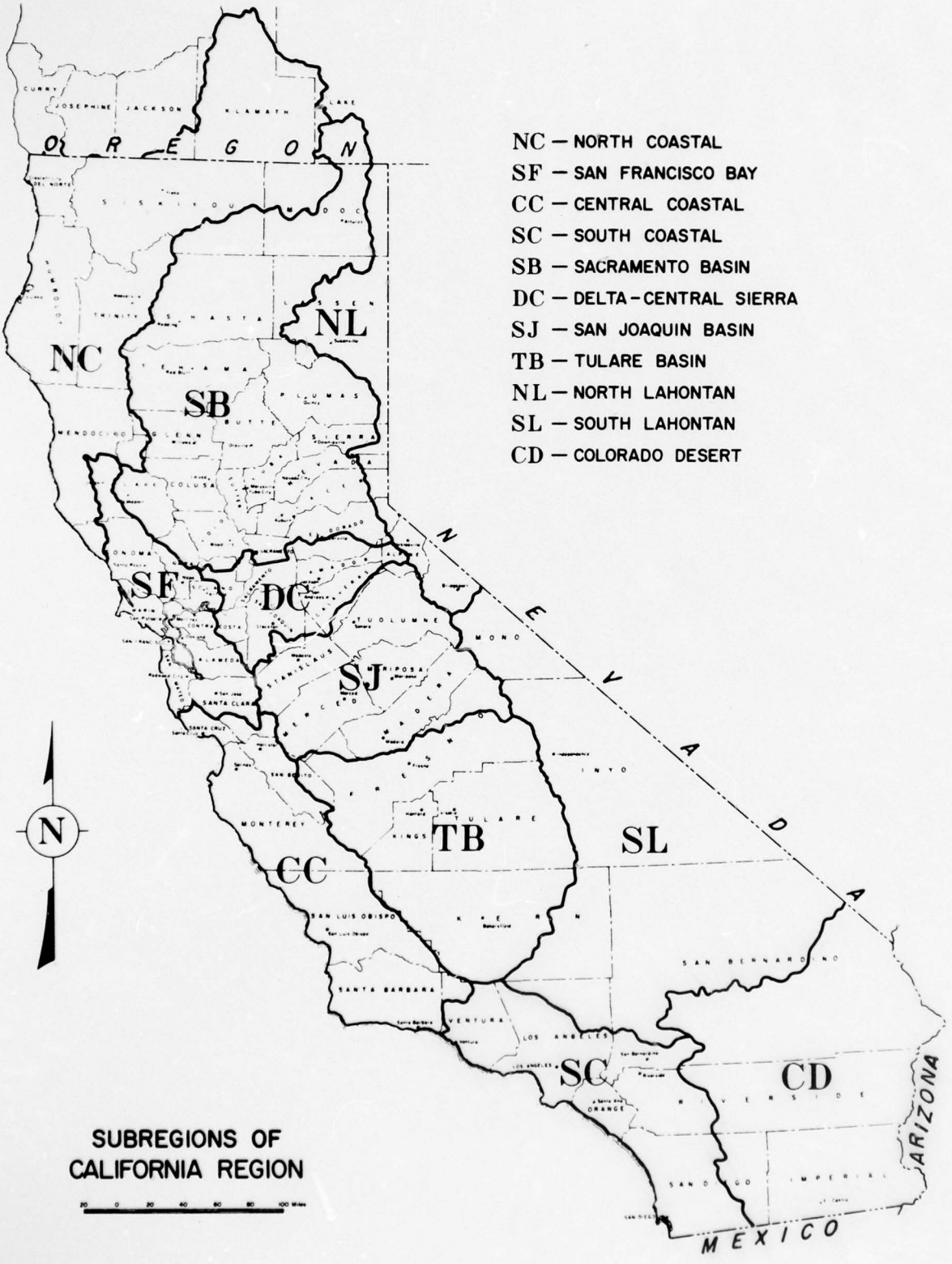
Continued

TABLE 4--Continued

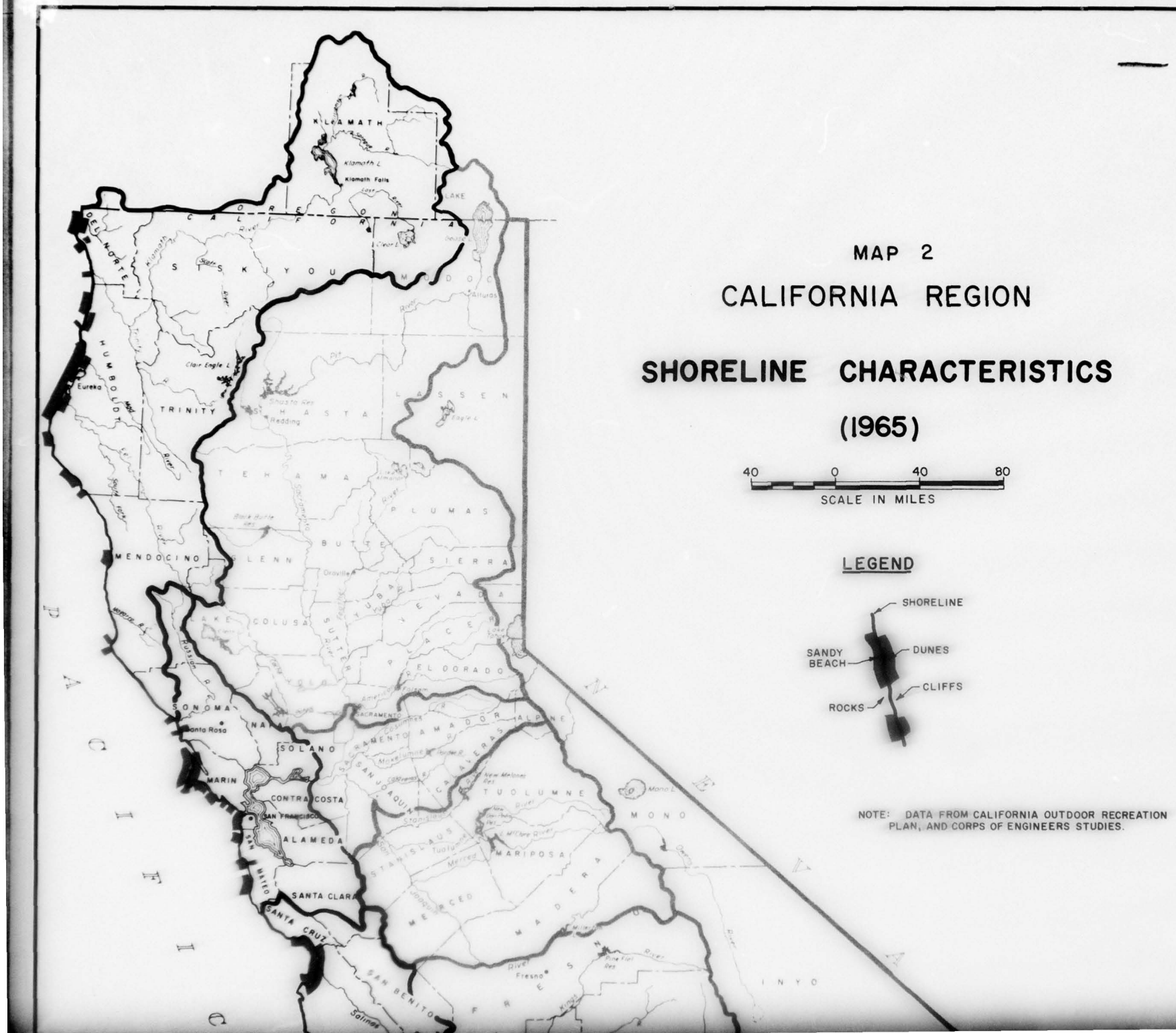
CALIFORNIA REGION

Estimated Shoreline Program Costs, in $1,000 (1965 prices)

Item	North Coastal Subregion	San Francisco Bay Subregion	Central Coastal Subregion	South Coastal Subregion	Region Total
	2001-2020 PROGRAM				
STRUCTURAL MEASURES:					
Installation costs					
Federal	3,600	4,550	4,000	2,300	14,450
Non-Federal	3,600	6,150	4,000	17,300	31,050
Subtotal	7,200	10,700	8,000	19,600	45,500
Annual OM & R					
Federal	0	0	0	0	0
Non-Federal	170	260	210	196	836
Subtotal	170	260	210	196	836
NON-STRUCTURAL MEASURES:					
Installation costs					
Federal	0	0	0	0	0
Non-Federal	1,230	150	7,160	230	8,770
Subtotal	1,230	150	7,160	230	8,770
Annual OM & R					
Federal	0	0	0	0	0
Non-Federal	10	0	0	0	10
Subtotal	10	0	0	0	10
2001-2020 PROGRAM TOTAL					
Federal	3,600	4,550	4,000	2,300	14,450
Non-Federal	4,830	6,300	11,160	17,530	39,820
Total	8,430	10,850	15,160	19,830	54,270
Annual OM & R	180	260	210	196	846


NC — NORTH COASTAL
SF — SAN FRANCISCO BAY
CC — CENTRAL COASTAL
SC — SOUTH COASTAL
SB — SACRAMENTO BASIN
DC — DELTA-CENTRAL SIERRA
SJ — SAN JOAQUIN BASIN
TB — TULARE BASIN
NL — NORTH LAHONTAN
SL — SOUTH LAHONTAN
CD — COLORADO DESERT
OREGON
NEVADA
ARIZONA
MEXICO
N
NC
NL
SB
SF
DC
SJ
TB
SL
CC
SC
CD
SUBREGIONS OF
CALIFORNIA REGION

MAP 1



MAP 2

CALIFORNIA REGION

SHORELINE CHARACTERISTICS

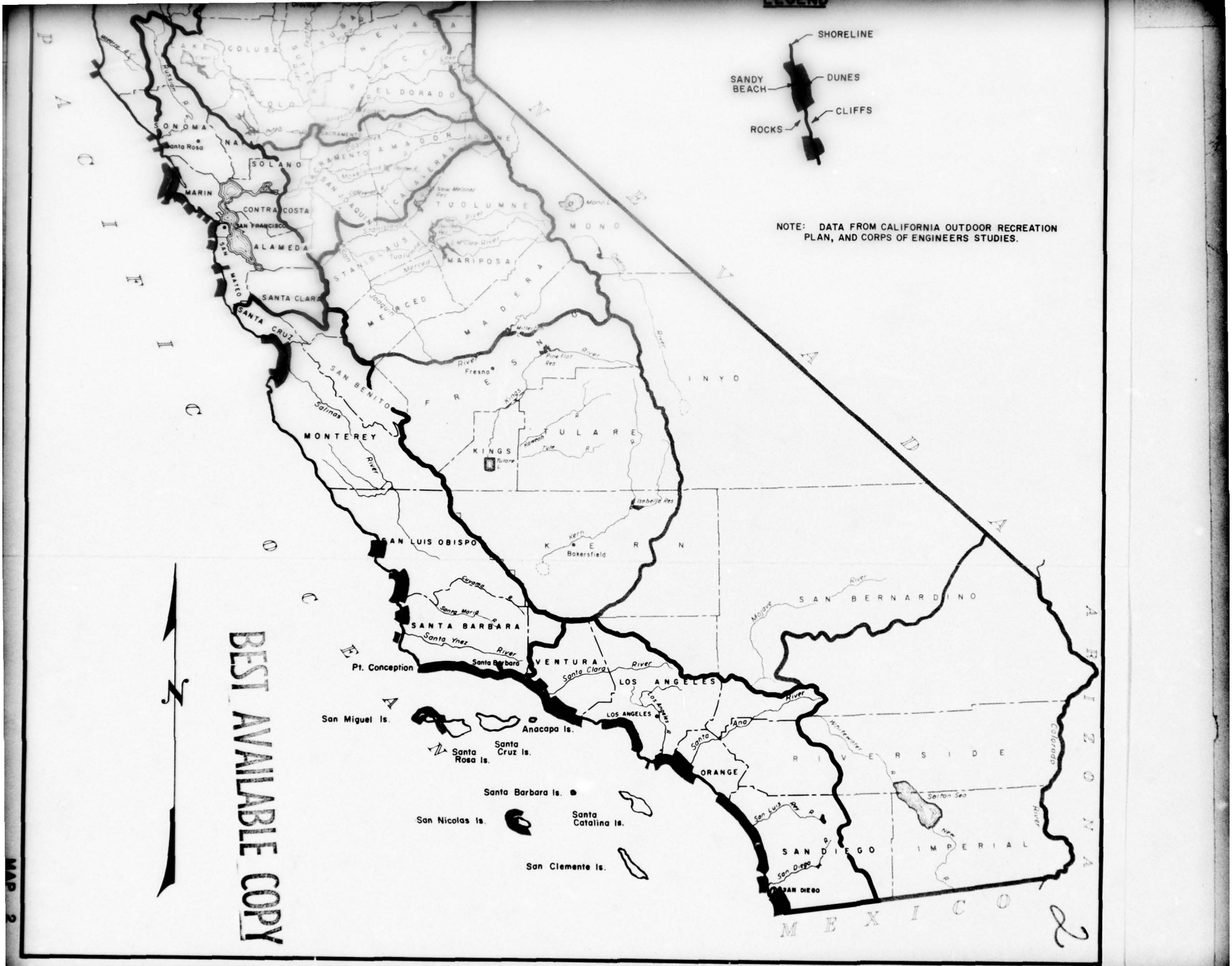
(1965)

40 0 40 80

SCALE IN MILES

LEGEND

NOTE: DATA FROM CALIFORNIA OUTDOOR RECREATION PLAN, AND CORPS OF ENGINEERS STUDIES.



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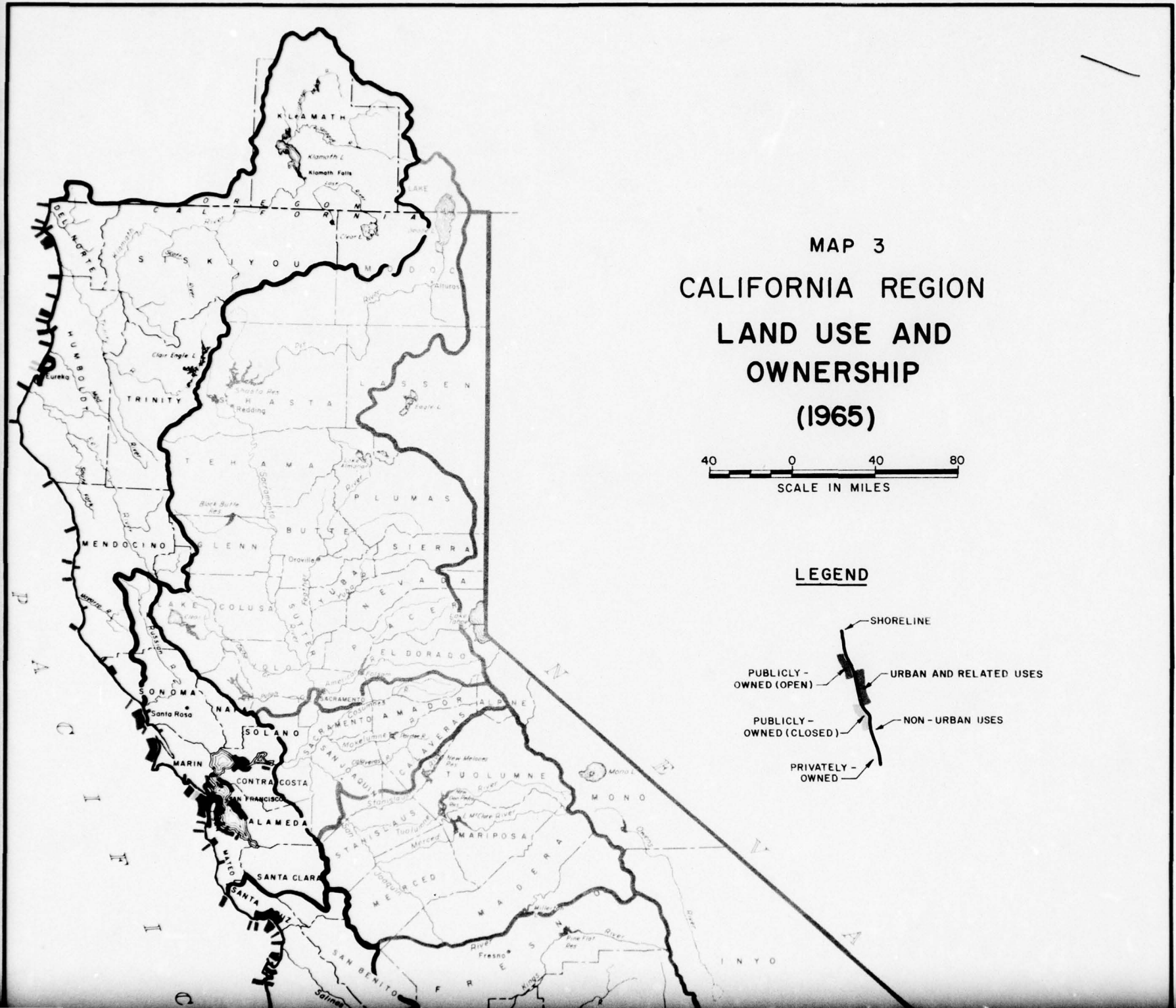
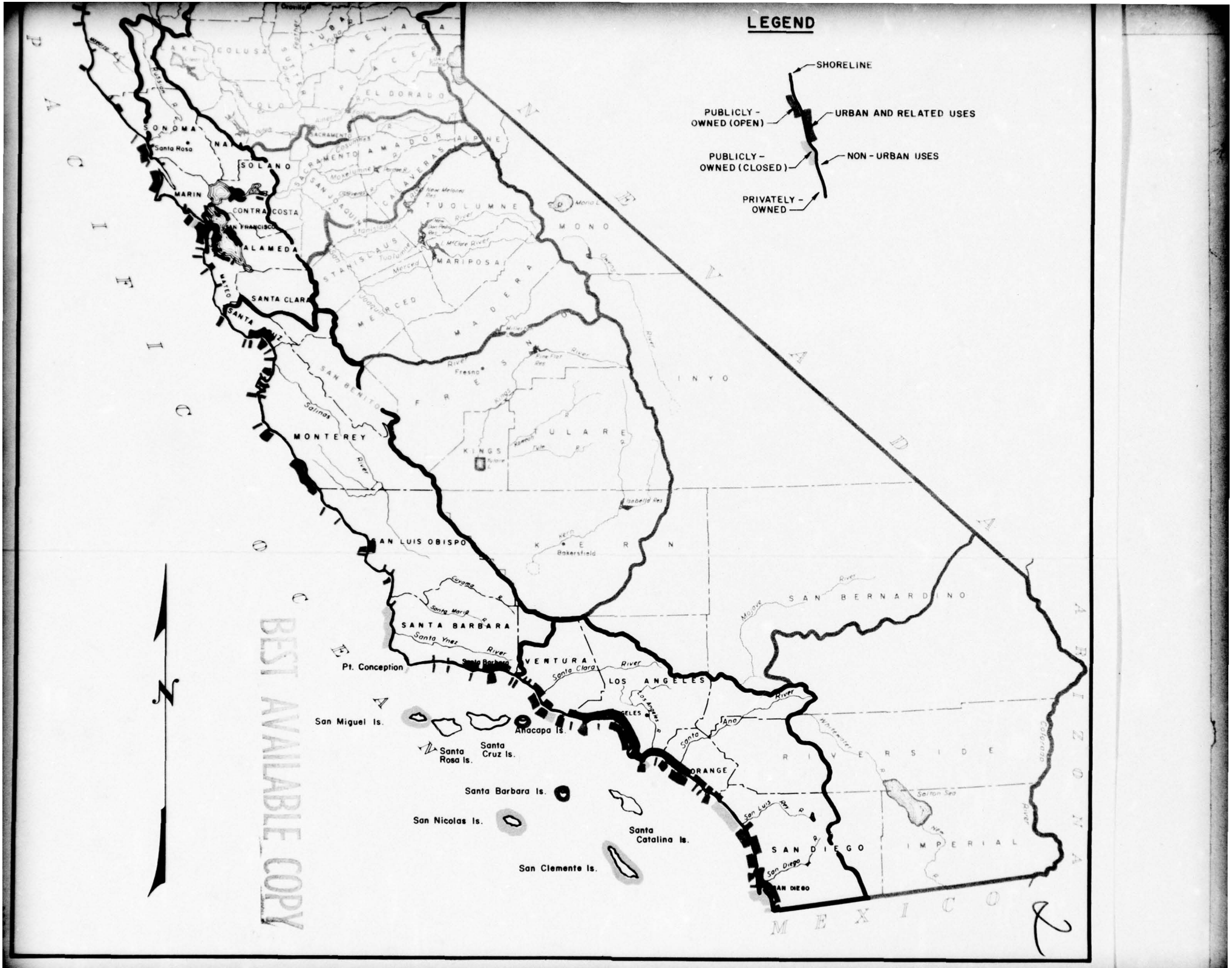
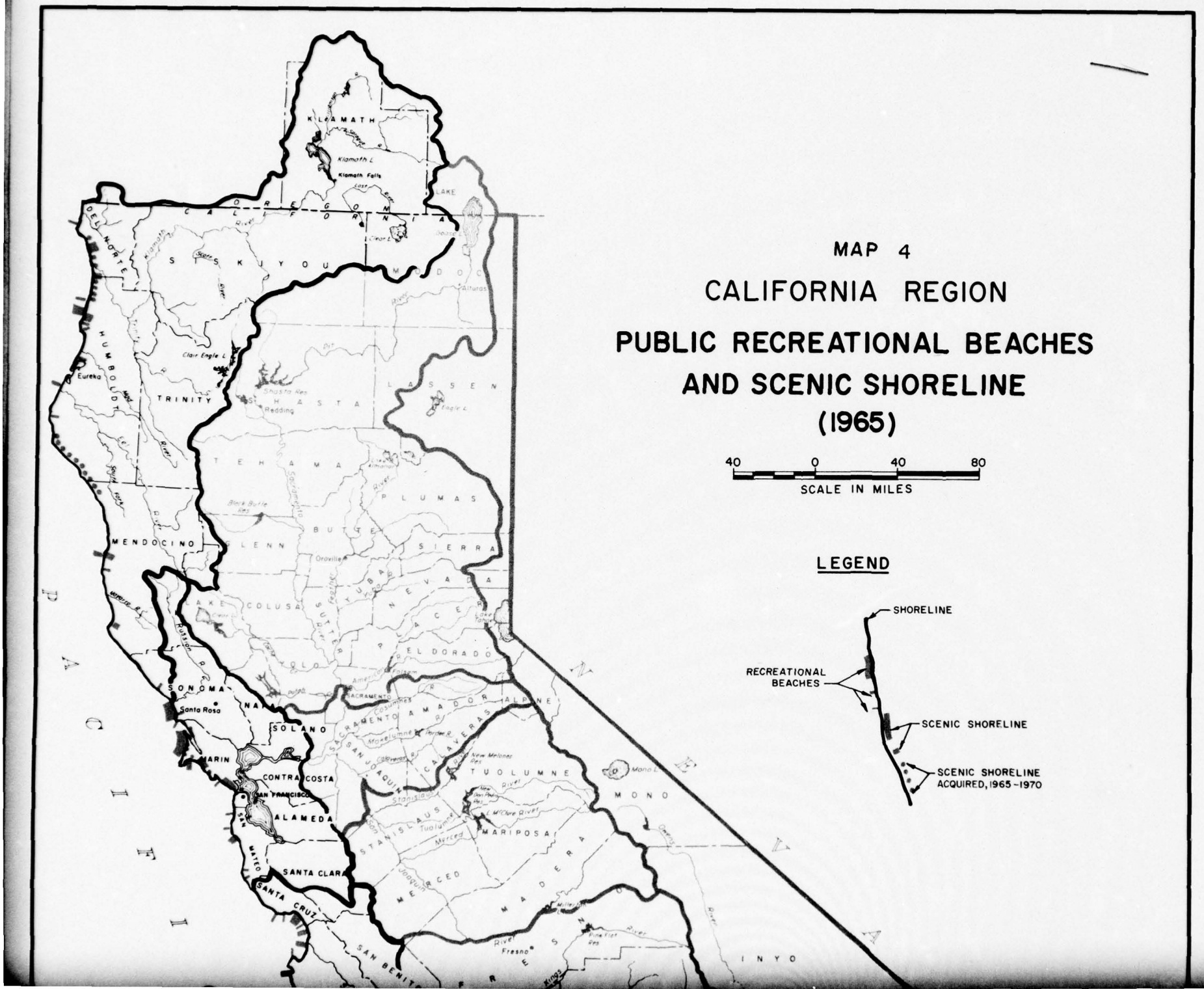
MAP 2


MAP 3
CALIFORNIA REGION
LAND USE AND
OWNERSHIP
(1965)
40 0 40 80
SCALE IN MILES
LEGEND
SHORELINE
PUBLICLY - OWNED (OPEN)
URBAN AND RELATED USES
PUBLICLY - OWNED (CLOSED)
NON - URBAN USES
PRIVATELY - OWNED
KLAMATH
Klamath Falls
DEL NORTE
HUMBOLDT
TRINITY
SISKIYOU
MODOC
LASSEN
SHASTA
Redding
TEHAMA
PLUMAS
BUTTE
Oroville
GLENN
SIERRA
MENDOCINO
COLUSA
NEVADA
PLACER
EL DORADO
SONOMA
Santa Rosa
NAPA
SOLANO
MARIN
CONTRA COSTA
SAN FRANCISCO
ALAMEDA
SACRAMENTO
AMADOR
ALPINE
CALAVERAS
TUOLUMNE
MONO
SANTA CLARA
SANTA CRUZ
SAN BENITO
MERCED
MARIPOSA
MADERA
Fresno
INYO
PACIFIC




MAP 4
CALIFORNIA REGION
PUBLIC RECREATIONAL BEACHES
AND SCENIC SHORELINE
(1965)
40 0 40 80
SCALE IN MILES
LEGEND
SHORELINE
RECREATIONAL BEACHES
SCENIC SHORELINE
SCENIC SHORELINE ACQUIRED, 1965-1970
KLAMATH
Klamath L.
Klamath Falls
LAKE
DEL NORTE
HUMBOLDT
Eureka
TRINITY
Clair Engle L.
SHASTA
Shasta Res.
Redding
LASSEN
Eagle L.
MODOC
Alturas
TEHAMA
PLUMAS
BUTTE
Oroville
GLENN
SIERRA
COLUSA
NEVADA
PLACER
Lake Tahoe
EL DORADO
MENDOCINO
SONOMA
Santa Rosa
NAPA
SOLANO
MARIN
CONTRA COSTA
SAN FRANCISCO
ALAMEDA
SAN MATEO
SANTA CLARA
SANTA CRUZ
SAN BENITO
AMADOR
ALPINE
CALAVERAS
TUOLUMNE
MARIPOSA
MONO
Mono L.
MADERA
MERCED
Fresno
INYO
PACIFIC


SHORELINE
RECREATIONAL BEACHES
SCENIC SHORELINE
SCENIC SHORELINE ACQUIRED, 1965-1970
PACIFIC OCEAN
NEVADA
ARIZONA
MEXICO
LAKE
COLUSA
SUTTER
YUBA
PLACER
EL DORADO
SONOMA
NAPA
Santa Rosa
SOLANO
MARIN
CONTRA COSTA
SAN FRANCISCO
ALAMEDA
SAN MATEO
SANTA CLARA
SANTA CRUZ
SACRAMENTO
AMADOR
CALAVERAS
SAN JOAQUIN
STANISLAUS
TUOLUMNE
MARIPOSA
MERCED
MADERA
MONO
INYO
FRESNO
KINGS
TULARE
KERN
Bakersfield
SAN BENITO
Salinas
MONTEREY
SAN LUIS OBISPO
SANTA BARBARA
Santa Barbara
VENTURA
LOS ANGELES
ORANGE
RIVERSIDE
SAN BERNARDINO
IMPERIAL
SAN DIEGO
Pt. Conception
San Miguel Is.
Santa Rosa Is.
Santa Cruz Is.
Anacapa Is.
Santa Barbara Is.
San Nicolas Is.
Santa Catalina Is.
San Clemente Is.
N
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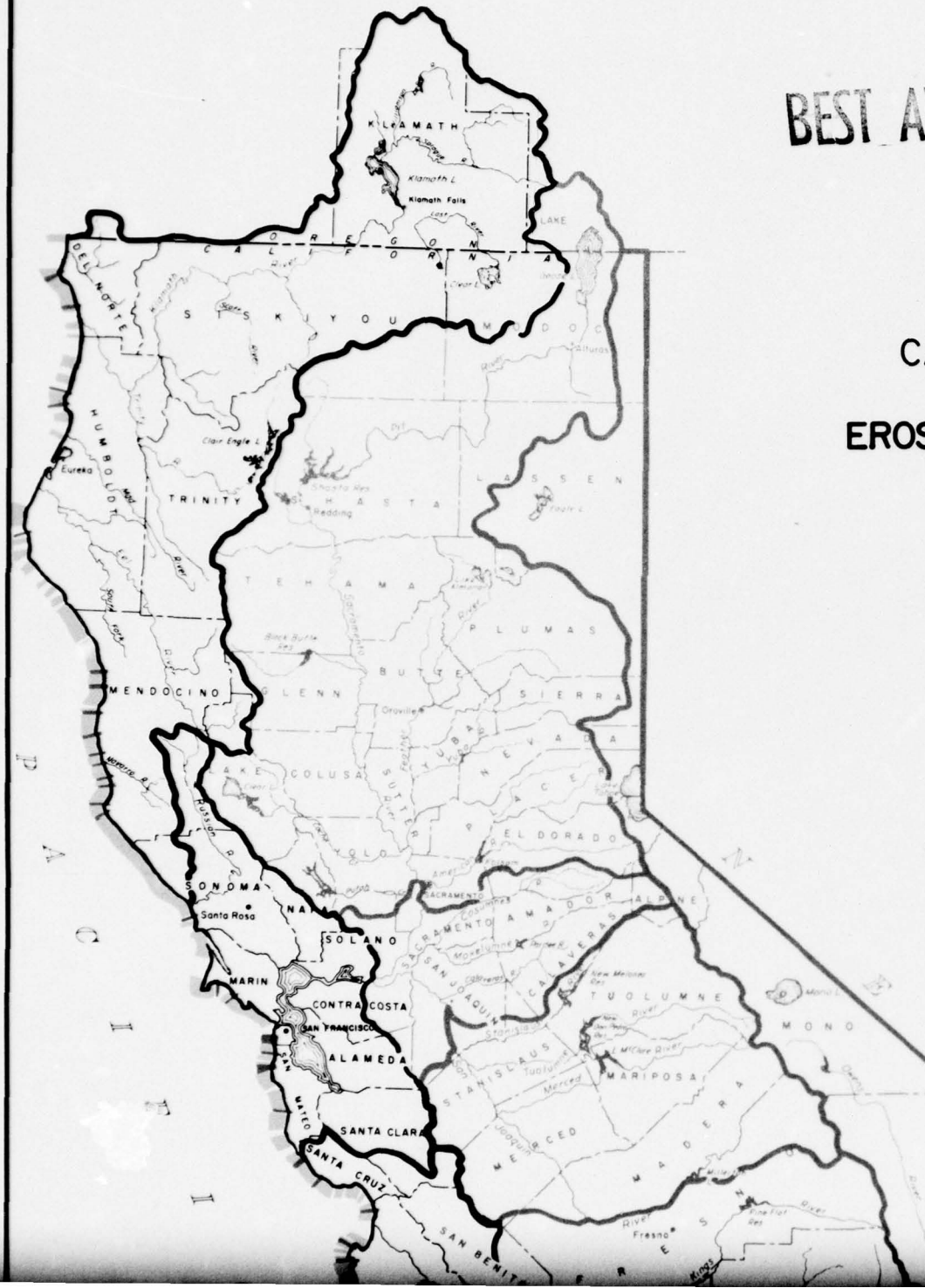


MAP 5

CALIFORNIA REGION

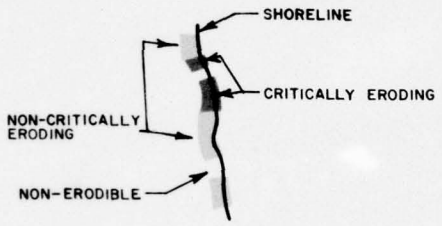
EROSION CHARACTERISTICS

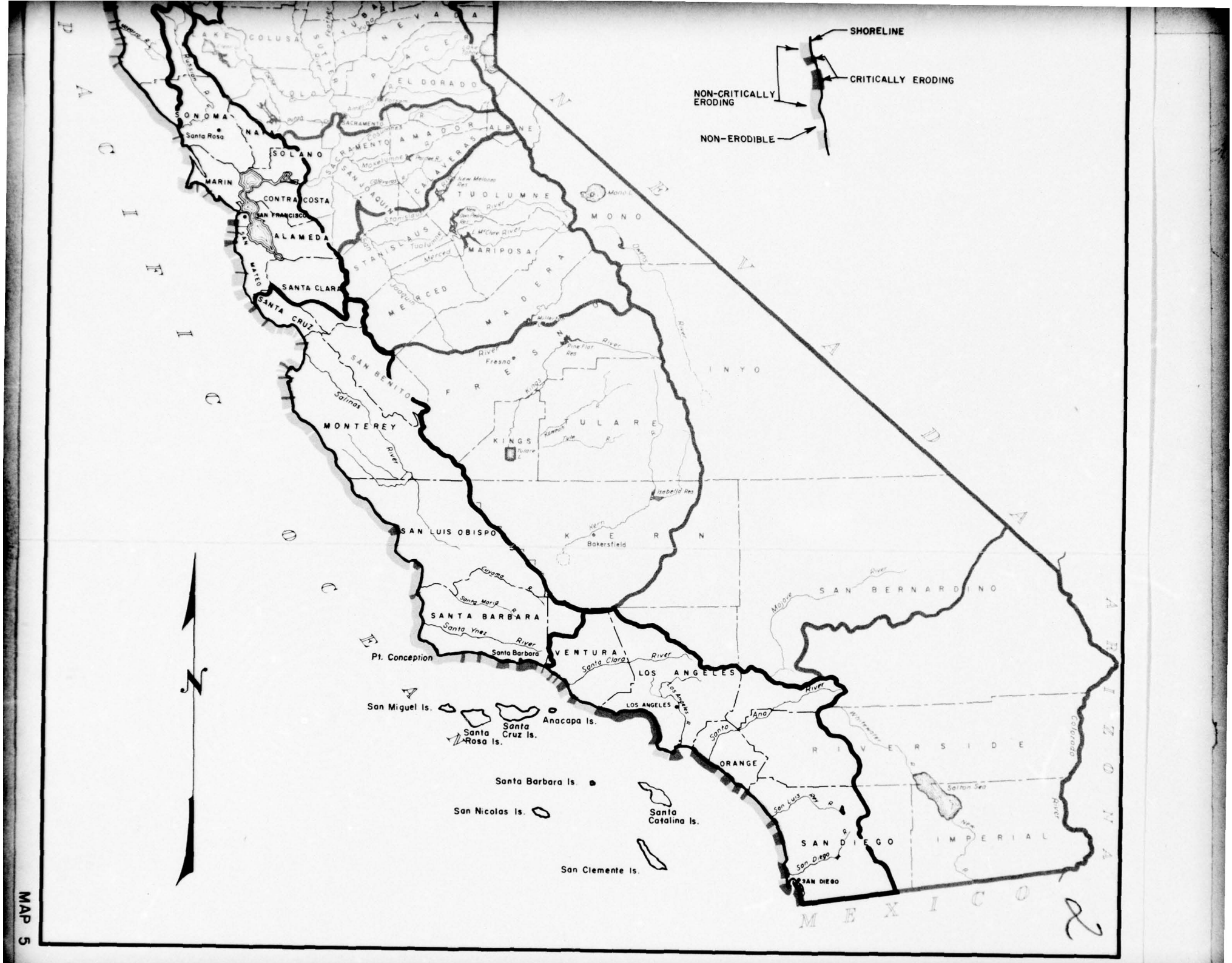
(1965)

40 0 40 80

SCALE IN MILES

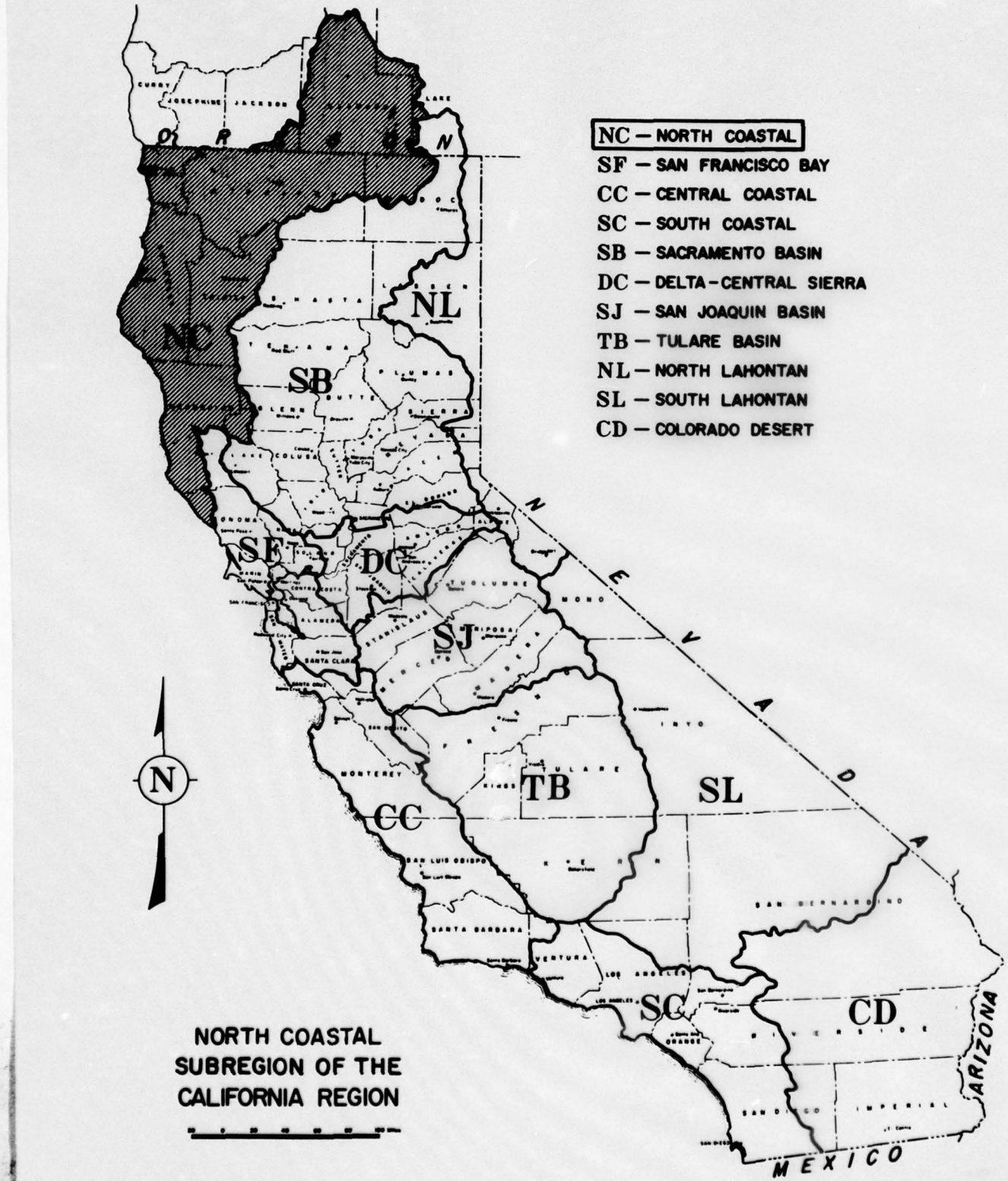
LEGEND




SHORELINE
CRITICALLY ERODING
NON-CRITICALLY ERODING
NON-ERODIBLE
PACIFIC OCEAN
NEVADA
PLACER
EL DORADO
AMADOR
ALPINE
SACRAMENTO
COLUSA
SONOMA
Santa Rosa
NAPA
SOLANO
MARIN
CONTRA COSTA
SAN FRANCISCO
ALAMEDA
SAN MATEO
SANTA CLARA
SANTA CRUZ
SAN JOAQUIN
CALAVERAS
TUOLUMNE
STANISLAUS
MARIPOSA
MONO
MERCED
MADERA
FRESNO
INYO
SAN BENITO
Salinas
MONTEREY
KINGS
TULARE
KERN
Bakersfield
SAN LUIS OBISPO
SANTA BARBARA
Santa Barbara
Pt. Conception
VENTURA
LOS ANGELES
SAN BERNARDINO
ORANGE
RIVERSIDE
IMPERIAL
SAN DIEGO
San Diego
MEXICO
San Miguel Is.
Santa Rosa Is.
Santa Cruz Is.
Anacapa Is.
Santa Barbara Is.
San Nicolas Is.
Santa Catalina Is.
San Clemente Is.
N

MAP 5

NORTH COASTAL SUBREGION



NORTH COASTAL SUBREGION OF THE CALIFORNIA REGION

NORTH COASTAL SUBREGION

Description of the Subregion

PHYSICAL CHARACTERISTICS

The North Coastal subregion encompasses an area of 23,417 square miles, including 5,711 square miles in southern Oregon, primarily in the County of Klamath. Within the State of California, it includes all of Del Norte, Humboldt and Trinity Counties, and parts of Mendocino, Siskiyou, Sonoma, Lake, Glenn and Modoc Counties. All of the subregion's counties having coastal shoreline are in California. These counties are Del Norte, Humboldt, Mendocino and Sonoma. The total shoreline length of the subregion is 332 miles. The opposite index map shows the relationship of the North Coastal subregion to the other subregions of the California Region.

The subregion is characterized by steep and rugged mountain terrain that is typical of the more mountainous areas of the California Region. The major mountain ranges in the subregion are the Klamath Mountains in northwestern California and southwestern Oregon, and the California Coast Range extending along the Pacific Ocean. These mountain ranges are the sources of the principal streams in the subregion--the Smith, Klamath, Eel and Mad Rivers.

With the exception of the Smith River and Eel River delta areas, the subregion has little or no coastal plain. Throughout most of the subregion, mountains and rolling hills extend out to the shoreline, creating some of the most scenic shoreline in the California Region.

The continental shelf off the subregion's shoreline is of variable width, ranging from a maximum of about 30 miles to a minimum of about one mile. Beyond the continental shelf, the ocean floor drops off from a depth of about one mile, at a distance of 30 to 50 miles offshore, to a depth of approximately two miles, at a distance of 100 to 150 miles offshore.

CLIMATE AND EXPOSURE

The North Coastal subregion has a temperate climate, characterized by mild summers and moderately cold winters along the shoreline. Average annual temperatures vary slightly from 53° F at Point Arena to 52°F at Eureka. In 1965, maximum temperature varied from 92°F at Point Arena to 80°F at Eureka. Minimum temperature ranged from 31°F at Point Arena to 29°F at Eureka.

Ocean temperatures of the subregion vary from winter temperatures in the low 50's to summer temperatures in the high 50's. Water temperatures are somewhat lower in the northern part of the subregion than in the southern

part. Temperatures in the shallower inshore waters are higher than temperatures in the deeper offshore waters during the summer months. However, temperature changes in offshore waters are less variable and the temperature range is significantly smaller. Accordingly, winter offshore temperatures are somewhat higher than inshore temperatures. North Coastal Subregion waters are generally too cold for swimming. In some confined water areas, higher temperatures may permit occasional swimming.

Rainfall varies from about 40 inches a year in the southerly portion of the shoreline to about 80 inches a year near the Oregon border. The rainy season, October to April, is about 7 months long, and is somewhat shorter in the southern part of the subregion than in the northern part.

Severe storms, winds and squalls occur frequently along the northern coast, particularly during the winter season. Heavy waves generated by storms in the North Pacific buffet the coast during the summer as well as winter months. Tsunami damage occurs from time to time along the northern coast, particularly in the Crescent City area.

Heavy fogs occur along the north coast most frequently during July, August and September. The months of December and January are relatively free from foggy weather. Typical heavy summer fogs often extend many miles offshore, return shoreward at sundown, and move offshore during the following day.

POPULATION DISTRIBUTION

The North Coastal subregion had a population of about 227,000 in 1965, which was approximately 1.3 percent of the total population of the California Region, estimated at 18,106,000. The largest city was Eureka, with a population of about 30,000. Tourists comprise a major part of shoreline visitors.

The subregion's population has been projected at 255,000 by 1980, 448,000 by 2000, and 884,000 by 2020. The 2020 subregion population represents about 1.6 percent of the projected regional population of 54,941,000 for that year.

ECONOMY

The principal economic activities of the subregion center around the forest resources with significant contributions from sports and commercial fisheries, agriculture, and recreation. The subregion has almost half the commercial forest land in the California Region and the volume of logs produced for all purposes has been well over half the regional total for a considerable number of years. Agriculture in the subregion is concerned primarily with dairying, beef production and field crops. Recreation is a very important economic base and will become more so in the future, especially along the shoreline area. Major recreation activities include sightseeing, marine and inland fishing, hunting, and the gathering of shellfish.

TRANSPORTATION

The subregion is served by a moderately developed transportation system that includes a north-south interstate highway along the coast; numerous connecting State, county and local roads; bus, air, and rail services; and two commercial harbors, Crescent City Harbor and Humboldt Harbor.

Access to shoreline areas is provided by State Highway No. 1 from the subregion's south boundary at Jenner to the vicinity of Rockport. Between the town of Rockport and the Eel River Delta, access to shoreline and beach areas is limited to local roads and trails. From the Eel River delta to the Oregon border, U.S. Highway No. 101 provides access to shoreline areas.

The Northwestern Pacific Railroad connects the Eureka-Humboldt Bay area with the San Francisco Bay area. Bus service is provided throughout the entire subregion. Eureka, Crescent City and Klamath Falls have commercial airports.

Existing Conditions in the Shoreline Zone

GENERAL

The study area covered by this report is confined to the shoreline zone, which is defined as the active erosive zone during the study period. This narrow zone is generally about 500 feet in width.

The subregion's shoreline zone includes steep mountainous reaches, wide river valleys and deltas, lagoons and bays, and sandy and rocky beaches; the backshore terrain varies from rolling hills to steep mountains and eroded seacliffs. Sandy beaches are generally narrow and limited in extent, and are exposed to winds and heavy seas. Beach cover varies from fine-grained and coarse-grained sands to pebbles, cobbles and larger rocks. Prominent offshore rocks and pinnacles are natural features of many of the beach areas. Other sandy beach areas are bounded by steep or near-vertical seacliffs ranging in elevation from 30 to 300 feet. Shoreline characteristics are shown in Map 2.

DESCRIPTION OF SHORELINE

General

Of the total of 332 miles of shoreline, about 80 miles are considered to be non-eroding or stable, with the remaining 252 miles in varying degree of erosion. Of the eroding shoreline, about 15 miles are eroding critically, threatening mainly highways and residential properties. The rate of erosion for the North Coastal subregion ranges from non-eroding to about two feet per year. The following subparagraphs describe the shoreline topography

and related problems by counties, north to south. Major locations are shown on Maps NC-1 through NC-4, at the end of this chapter.

Del Norte County

This county has a shoreline length of about 46 miles, or about 14 percent of the total shoreline of the subregion. From the Oregon border to the mouth of the Smith River, a distance of about 4 miles, the shoreline is generally rocky, backed by U.S. Highway No. 101, which parallels the shoreline about 500 feet inshore. Pelican State Beach is located within this reach about 0.5 mile from the Oregon border. This beach is primarily used for fishing and has an ocean frontage of about 0.2 mile. A small county park with about 200 feet of ocean frontage is located south of the State beach. With the exception of a group of residential and commercial establishments at the mouth of the Smith River that cater to sports fishermen, land use between the highway and shoreline is predominantly agricultural. Erosion is occurring at a slow rate and is of a non-critical nature.

From the mouth of the Smith River to Point St. George, a distance of about 12 miles, the shoreline is comprised of dark-colored sandy beach backed by active sand dunes. Further inshore, the area includes Lake Earl and Lake Talawa, which drain into the ocean. At one time, in 1959, the National Park Service stated that this shoreline reach possessed fine recreation and biological values and recommended acquisition and preservation of as much of this land as possible for future public recreation use. However, since that time, much of the dune area has been subdivided and present activities indicate that the entire area will be subdivided in the near future. At the present, 1 mile of improved public beach and 1 mile of improved private beach are located in this reach. Del Norte County has placed high priority for acquisition of an additional mile of beach in this reach. In recent history, this reach of shoreline has been fairly stable. The sand dunes, although migrating, have been in equilibrium with respect to sand supply, and no noticeable erosion has occurred. However, encroachment by man may alter this balance and may lead to serious erosion problems in the future.

The shoreline zone between Point St. George and Enderts Beach, a distance of about 10 miles, consists of a combination of unusually scenic shoreline and recreation beaches. The northern portion, which includes the shoreline of Crescent City and its harbor, has a number of overlooks providing views of the scenic shoreline, with its many offshore rocks and rugged headlands. The tidal area is noted for its scientifically-valuable invertebrate life. A sandy beach (Pebble Beach) with about 1.5 miles of ocean frontage, is located between Point St. George and Crescent City. The southern portion of this shoreline reach contains a curving, dark-colored sandy beach (Shell Beach) that extends 3.5 miles south from the Crescent City Harbor breakwater at Whaler Island to a 200-foot rocky vista point that separates Shell Beach from Enderts Beach. This latter beach is narrow and sandy, and is backed by a steep headland; access is very difficult. The immediate inshore area

of Shell Beach is relatively flat with a few small marshes; the foreshore is gently sloping. The National Park Service, State Division of Beaches and Park, and the County of Del Norte all have proposed acquisition of parts of this scenic shoreline for future public use. So far, Del Norte County has acquired about 0.8 mile of Pebble Beach. The National Park Service has acquired 2 miles of Shell Beach as part of the 56,500-acre Redwood National Park. This acquisition became the northern limit of the Park's continuous 37-mile ocean frontage, which extends south to the vicinity of Stone Lagoon in Humboldt County. At the present time, part of the Pebble Beach shoreline is eroding critically, with a potential threat to a public road and residential properties beyond the roadway. The remaining shoreline in this reach is also eroding, but at a non-critical rate. This reach also has a history of severe damage from tsunamis. Seven tsunamis have been recorded between 1946 and 1964; the most severe occurred on 28 March 1964 and caused damage totalling $11 million with a loss of 8 lives. A study is underway by the Corps of Engineers to determine the feasibility for providing protection to Crescent City from future tsunami damage.

The remaining 20 miles of Del Norte County shoreline, with the exception of a few pocket beaches and a sandspit at the mouth of Klamath River, are rocky, and are backed by vertical cliffs and rugged terrain. The Del Norte Coast Redwoods State Park, with an area of nearly 6,000 acres and shoreline frontage of about 7 miles, is located within the shoreline zone of this reach. As mentioned previously, this entire reach is also within the boundary of the Redwood National Park. The Klamath River sandspit formation includes a south spit about 3,500 feet long and a smaller, more sheltered spit on the north side of the river. The only other accessible beach area in this reach is a small beach at False Klamath Cove about three miles north of the Klamath River. Erosion characteristics in this reach include non-eroding rocky shoreline, non-critical erosion and critical erosion. The latter is occurring at False Klamath Cove with potential threat to the embankment of U.S. Highway No. 101.

Humboldt County

This county has a shoreline length of about 121 miles, or about 36 percent of the total shoreline of the subregion. The shoreline zone from the Del Norte County line to Mussel Point, a distance of about 10 miles, consists of a small portion of the Prairie Creek Redwoods State Park and about 8.5 miles of wide sandy beach backed by eroded and near-vertical cliffs known as Gold Bluffs. The beach area along the State Park is rocky, backed by cliffs. The sandy beach fronting Gold Bluffs is relatively clean and varies from 300 to 1,500 feet in width. The bluffs attain heights up to 250 feet and are partly covered by Sitka spruce. The area beyond the bluffs is rugged in character with steep side canyons and sharp ridges. Fern Canyon, within this area, is of outstanding beauty, and is covered with a solid growth of five-fingered ferns. This is one of few places

where Roosevelt elk are found near the seashore. Evidences of early day placer mining within the area also create historical value. U.S. Highway No. 101 parallels this reach about 1 to 3 miles inland. Present access from the highway is limited to jeep trails; however, this area has been acquired since 1965 as part of the Redwood National Park and improved future public access is anticipated. Some non-critical erosion has taken place along this reach; however, by and large, the beach area along the Gold Bluffs is fairly stable.

The 15-mile reach between Mussel Point and Patricks Point is the reach of the lagoons. Three lagoons, separated from the ocean by sandbar barriers, occupy about 8.5 miles of shoreline in the middle of this reach. From north to south, these lagoons are Freshwater Lagoon, with a water area about 200 acres; Stone Lagoon, with about 580 acres; and Big Lagoon, with about 1,370 acres. The sand barriers fronting the lagoons vary from about 500 to 600 feet in width. These lagoons are basically bodies of salt water with periodic isolation from the ocean when the barrier bars remain solid. Freshwater Lagoon is the least brackish of the three. Biologically, the lagoons provide good habitat for a variety of waterfowl; and their shoreline, upland and ocean frontage provide excellent opportunities for seashore and related aquatic recreation activities. The entire ocean shoreline, including the sand barriers, is in State ownership; nearly 6 miles are within the Dry Lagoon State Beach and Park. The northern boundary of this State Park, in the vicinity of the Stone Lagoon, is also the southern shoreline boundary of the Redwood National Park. About one mile of U.S. Highway No. 101 traverses the sand barrier fronting Freshwater Lagoon and continues along the eastern shoreline of Stone and Big Lagoons. The shoreline north of the lagoons to Mussel Point, comprises about 3 miles of narrow sandy beach with steep and rugged backshore terrain; and includes a 1,500-foot-long and 200-foot-wide sandspit at the south side of the mouth of Redwood Creek. The sandspit is part of the Humboldt County Redwood Creek Park, which extends south along the beach for another 2,000 feet. The shoreline south of the lagoons includes Big Lagoon Park, a small county park, and Patricks Point State Park, which has an area of about 430 acres and a coastal frontage of over 2 miles. Camping and picnicking facilities and scenic vista point are available at the State Park, as are hiking trails to fishing and agate-collecting beaches. Minor erosion of a non-critical nature is taking place north of Redwood Creek. The sand barriers separating the lagoons from the ocean have been relatively stable and noticeable erosion has not occurred within recent history. South of the lagoons, critical erosion has occurred within the Big Lagoon County Park on about 0.5 mile of low-lying headland, with a potential threat to a group of residential dwellings. The shoreline south of the county park has a narrow beach with rugged and steep backshore terrain. Along Patricks Point State Park the shoreline is rocky and erosion is of a non-critical nature.

The reach between Patricks Point and Little River, about 10 miles in length, is an unusually scenic shoreline, with many offshore rocks, reefs, coves and rugged headlands, the most prominent of which are

Elk Head and Trinidad Head. The shoreline between these two headlands forms a small cove and is especially scenic, with such landmarks as Off Trinidad Rock and Pewetole Island. Trinidad State Beach, which is an excellent sandy beach about 0.2 mile long, occupies a portion of this cove just north of Trinidad Head. Immediately south and east of Trinidad Head is a sheltered cove which forms the shoreline of the town of Trinidad. A small-craft harbor is being considered for this cove. Farther to the south, and just north of Little River Rock, is Luffenholtz Beach, a county fishing beach. U.S. Highway No. 101 parallels this entire reach no more than one mile inshore. A county road runs along the shoreline between the town of Trinidad and Little River. Erosion in this reach ranges from none to critical. The bluff behind Trinidad State Beach is eroding critically; however, a single dwelling is the only improvement in danger of being damaged.

Between Little River and the mouth of the Eel River, a distance of about 30 miles, the shoreline zone is almost continuous sandy beach backed by active sand dunes that extend up to 0.5 mile inland. The beach is interrupted only by the outlets of the Mad and Eel Rivers and the entrance to Humboldt Bay; and includes the north and south sandspits of Humboldt Bay and the sandspit at the north side of the mouth of the Eel River. This reach of the shoreline has the highest concentration of population in the entire subregion, including the Eureka-Arcata complex around Humboldt Bay with a 1965 population of about 60,000. The coastal plain of the subregion is also the widest in this reach, extending inland some 10 miles at the Eel River delta. Rugged and steep backshore terrain exists only in the northernmost 3 miles of the reach behind Little River State Beach and Clam Beach (County), which have ocean frontages of about 0.8 mile and 0.5 mile, respectively. Like most beaches in the subregion, these beaches are primarily used for clamming, surfing and picnicking. Immediately south of Clam Beach, the State and County also own several shoreline parcels with aggregate ocean frontage of about 2 miles. The remainder of the reach is a relatively wide and gently sloping sandy recreation beach backed by active sand dunes. The transition from ocean through beach, sand dunes and coastal forest to tidal marsh is an excellent example of ecological succession, and the mudflat-tidal marsh is one of the most nearly optimum shorebird habitats to be found along the entire Pacific Coast. Public ownership of the shoreline between Mad River and Samoa totals about 2 miles, including the Mad River County Park with nearly a mile of ocean beach immediately south of the mouth of Mad River. From Samoa to the Humboldt Bay entrance, public ownership includes about 2.5 miles at the tip of the North Spit. The bayside of the North Spit is developed with extensive residential, commercial and industrial uses, most of which are associated with the lumbering industry of the Humboldt Bay area. The mudflats, salt marshes, and sloughs adjacent to the South Spit support a vast population of waterfowl, shorebirds and marine birds and the sandspit itself receives heavy use for picnicking, clamming, surf fishing and waterfowl hunting. The aquatic portion is the wintering ground for one of the largest concentrations of black brant geese on the Pacific Coast and this area possesses the necessary

attributes which qualify it as a waterfowl refuge. The entire ocean frontage of the South Spit is in private ownership. Further to the south, the State owns about 2.5 miles of the sandspit on the north side of the mouth of the Eel River. This narrow spit, together with a number of sloughs, forms the North Bay of the Eel River delta. Inshore land use is predominantly for agriculture. Both critical and non-critical erosion are occurring in the northernmost 2 miles of this reach, with critical erosion to a county road accounting for about 10 percent of the total. The remaining 28 miles of the shoreline zone consist primarily of active sand dunes and sandspits that are relatively stable with respect to sand supply and loss. No noticeable erosion has been observed

Sandy beach, sand dunes, inshore sloughs and agricultural land occupy the northerly 4 miles of the reach from the mouth of the Eel River to Cape Mendocino, a total distance of about 15 miles. The sand dunes are privately owned. A small County park, Centerville Beach Park, is located at the southern limit of the dunes and is well patronized by picnickers and beach strollers. From the County park to the Coast Guard Reservation at Cape Mendocino, the shoreline consists of a narrow beach immediately backed by steep, rugged, mountainous terrain. In the vicinity of Cape Mendocino, the coastline is exposed, with relatively deep water offshore and a sheer, rocky shoreline. This shoreline, together with many offshore rocks, produces a unique scenic view of spectacular wave action. Access to this area is limited to a county road; no access is available to the beach. Erosion characteristics range from non-eroding or stable sand dunes and rocky cliffs, to non-critical erosion of the less rocky shoreline.

From Cape Mendocino to the Mendocino County line, a distance of about 40 miles, the shoreline is typically rocky and irregular, with many offshore rocks and submerged reefs. This entire segment, as well as almost 10 miles of shoreline south of the Mendocino County line, are now a part of the King Range National Conservation Area. Beach areas are few and remote. The entire reach of the shoreline is uninhabited with the exception of a subdivision development at Shelter Cove, located about 3 miles north of the Mendocino County line. Access to the shoreline consists of a county road that runs along the shoreline for about 4 miles just south of Cape Mendocino, and a county road into Shelter Cove from U.S. Highway No. 101. In between these two points, the shoreline is inaccessible for over 30 miles. About 11 miles south of Cape Mendocino, a sandspit-lagoon formation at the mouth of the Mattole River provides one mile of beach for potential public use. At the present, this beach is inaccessible. A half-mile reach of the county road south of Cape Mendocino is subject to critical erosion. Otherwise, the erosion characteristics of this reach are about equally divided between non-eroding rocky cliffs and non-critical erosion of less rocky shoreline.

Mendocino County

The shoreline length of Mendocino County is about 120 miles, or 36 percent of the total shoreline of the subregion. The shoreline zone between

the Humboldt County line and Cape Vizcaino, a distance of about 24 miles, consists almost entirely of rugged mountains and cliffs. Except for a few scattered cattle ranches, the entire shoreline zone is uninhabited. This reach is devoid of beaches and access is limited to county roads that are within 500 feet of the shoreline in several places. State Highway No. 1 parallels the southernmost 4 miles of this reach about 1 mile inshore. Erosion characteristics in this reach are mainly non-critical, with a short reach of non-eroding rocky cliffs. A county road is subject to critical erosion in spots.

From Cape Vizcaino to the mouth of the Ten Mile River, a distance of about 15 miles, the shoreline zone includes two small communities, Westport and Newport, and the undeveloped Westport-Union Landing State Beach. Westport is the service center for the surrounding rural area. The sandy beach has a shoreline frontage of about 2 miles and a total area of about 32 acres. Present use of the beach is primarily for fishing. The remaining beach area of this reach is generally rocky and not suitable for recreation use. State Highway No. 1 runs along most of this reach from about 100 feet to 1,000 feet inshore. The shoreline of the northernmost 4 miles of this reach is rugged with near-vertical cliffs. The remaining shoreline is characterized by rolling hills and nearly flat bench land. Land use between the shoreline and the State highway is primarily agricultural. This entire reach is eroding, but erosion is mostly of a non-critical nature. Portions of the State highway are subject to critical erosion, including a 1-mile reach just north of the State beach.

The 11-mile shoreline reach between the mouths of the Ten Mile and Noyo rivers consists mainly of a wide sandy beach south of the Ten Mile River, MacKerricher State Park and the city of Fort Bragg. The beach extends south of Ten Mile River for about 4 miles. The beach itself is about 100 feet wide backed by sand dunes extending up to a mile inland. The sandy beach and active sand dunes are composed of almost black sand and are bounded on the east by a line of cliffs from 40 to 80 feet in height. The land is owned by a lumber company and is closed to the public. The main use of the coastline is as a right-of-way for a high speed logging road. The State Division of Beaches and Parks has termed this beach one of the finest in Northern California. MacKerricher State Park contains about 280 acres and has about 3.5 miles of shoreline. The shoreline fronting the park is rocky and steep with many submerged rocks and reefs; it is backed by vertical cliffs. Access to the park is by way of State Highway No. 1. The Fort Bragg area contains about 3 miles of very rocky and scenic shoreline. Fort Bragg, with a population of about 4,400, is the largest coastal city in the county, and is an important lumbering and tourist center. The shoreline zone in this area contains a number of municipal structures, an airstrip, boat launching ramps and lumbering facilities. State Highway No. 1 parallels the shoreline in all 11 miles of this reach at a distance of 300 feet to a mile from the ocean. Erosion in this reach ranges from non-eroding sand

dunes to critical erosion of several sections of the logging road and industrial properties at Fort Bragg. The remaining shoreline in this reach is eroding also, but erosion is of a non-critical nature.

From the Noyo River southward to the town of Mendocino, a distance of about 14 miles, the shoreline is rugged and scenic with steep rocky cliffs extending to the water's edge. The town of Mendocino is a small community of about 1,100 residents on the north side of Mendocino Bay. State Highway No. 1 runs parallel to, and within 0.5 mile, of the shoreline. Land use along the coast is predominantly agricultural, and the area is sparsely populated. The entire shoreline is privately-owned with the exception of the 0.5 mile shoreline in the Federal light station at Point Cabrillo and the 1-mile shoreline in Russian Gulch State Park, located about 9 miles south of Fort Bragg on State Highway No. 1. The park contains about 1,120 acres with camping and picnicking facilities and a small fishing beach. Caspar Point, 5 miles south of Fort Bragg and adjoining the small community of Caspar, and the coast immediately north of Mendocino both have high recreational potential because of the unspoiled ecology of the area. These two areas, containing about 2.0 miles and 1.5 miles of scenic shoreline, respectively, include 40- to 60-foot rock bluffs that drop abruptly from flat grassy tableland to the ocean. Small coves and inlets, shallow reefs and numerous offshore rocks add to the scenic interest of these areas. This whole reach is eroding to some degree. About 2 miles of the shoreline is undergoing critical erosion, endangering residential properties at Noyo and Caspar, and parts of State Highway No. 1.

The 20-mile reach of shoreline from Mendocino to the town of Elk is rugged, irregular, steep and rocky along its entire length. The area is spectacularly scenic, with many small coves, offshore rocks and submerged reefs that form unusual surf patterns and tidal pools. All of the shoreline is privately owned except for the ocean frontage of Van Damme Beach State Park. Van Damme beach is at the mouth of the Little River and is about 100 feet wide and 1,500 feet long, flanked by 45-foot-high vertical cliffs. Another sandy beach, about 200 feet wide and 1,300 feet long, is located at the mouth of the Navarro River. This beach is flanked by near-vertical cliffs which rise to a maximum height of 130 feet. Between Mendocino Bay and the Van Damme Beach State Park is an exposed scenic headland composed of 50 to 60 foot rock bluff about 2.5 miles long. This scenic headland has excellent geologic interest and an abundance and variety of marine life. Most of the land is in agricultural use and is sparsely populated. State Highway No. 1 parallels this reach, usually not more than 0.5 mile inshore. Erosion is taking place to some degree along the entire reach, with critical erosion occurring on a total of about 2 miles and threatening sections of State Highway No. 1 and residential properties in the vicinity of the town of Elk and the mouth of the Navarro River. The remaining shoreline is eroding also, but not critically.

The 15 miles of coast between Elk and Point Arena contains two basic types of shoreline. The northern 9 miles are generally rocky, with a relatively flat backshore area, while the southern 6 miles contain flat sandy beaches and dunes extending up to 0.8 mile inland. The northern section is not as rugged, but some cliffs rise as much as 130 feet above the sea. The land is privately owned, sparsely populated and is used as grazing land. The southern section contains a fine sandy beach 400 to 600 feet wide and about 5.5 miles long. The beach is backed by sand dunes and low terraces about 15 feet in height. About 2.5 miles of this reach are within the Manchester State Beach, a 650-acre beach used mainly for fishing. This beach is one of the few extensive beaches in northern California that retains its natural seashore qualities. A Coast Guard station and lighthouse is at the southern end of the beach, at Point Arena; and an Air Force radar station is located at the northern end of the State beach. State Highway No. 1 parallels the coast over the entire reach at a distance from several hundred feet at the northern portion to about 3 miles at Point Arena. Erosion in this reach ranges from non-eroding sand dunes to critical erosion of small sections of the State highway, a number of private residents and and commercial establishments. The majority of the shoreline is not critically eroding.

The next reach, 21 miles, from Point Arena to the Gualala River on the Mendocino-Sonoma County line, is a rugged and irregular coastline with numerous offshore rocks and submerged reefs. The land is still predominantly in agricultural use but the area is more heavily populated than some of the other north coastal reaches. The towns of Point Arena and Gualala, with a total population of about 1,200, mark the northern and southern ends of this reach. State Highway No. 1 skirts the coast in this reach; the area has frequent dwellings (mostly second homes) on either side of the highway. There are also several lumber mills and small fish landings in the area. This scenic reach is readily accessible from inland by way of several county roads. A small scenic headland, Haven's Neck, has been suggested for a park by the National Park Service and in the Mendocino County Master Plan. This rocky promontory, located about 7 miles north of the Gualala River, is connected to the mainland by a narrow natural causeway and offers magnificent views of an extensive stretch of the coastline. A small sheltered beach is located on the north side of the promontory. Sea lions and whales frequent this section of the coast and can be viewed especially well from Haven's Neck. The bluffs in this reach rise up to 100 feet vertically. The entire reach is subject to erosion, but only the land around the lighthouse at Point Arena, small sections of State Highway No. 1 and a number of residential structures at different locations are threatened by critical erosion.

Sonoma County

Of the total of 62 miles of coastal shoreline in Sonoma County, 44 miles are in the North Coastal subregion. The great majority of this portion of the County shoreline is rocky, rugged, scenic and abounding in marine life.

The first 20 miles of Sonoma County shoreline from Gualala River to Horseshoe Point is composed of two basic types: the northern 10 miles are rocky with 20-foot cliffs along the shore, backed by a gently sloping plateau about one-half mile wide with mountains beyond; the second half of this reach is similarly rocky but with little or no bench land and with mountains extending close to the shoreline. The northern section has been developed into a housing area of expensive second homes. The southern section is virtually uninhabited and is used primarily for grazing. The northernmost mile of this reach has sandy beach formed by a sandspit at the mouth of the Gualala River and is owned by Sonoma County. A lagoon is formed at the river's mouth when the sandspit closes the entrance to the river during the summer months. The County has planned to develop this property into a major recreational area. This reach of the shoreline is very scenic and can be viewed from State Highway No. 1, which runs with one-half mile of the shoreline. Access from inland is limited and difficult. Erosion is non-critical, except for a very small section of State Highway No. 1, where critical erosion endangers the road.

The reach from Horseshoe Point to Fort Ross State Historic Park, a distance of about 15 miles, has the rugged, rocky coastal characteristics of much of North Central California. The area is very scenic with many submerged and exposed offshore rocks, eroded headlands and sheltered tidal coves. Bluffs 20 to 50 feet high overlook the ocean along much of this reach. The shoreline zone is sparsely populated and is used either for agriculture or State parks. There are three State parks within this reach: Kruse Rhododendron State Reserve, located about 0.5 mile inland; Salt Point State Park, with about 3.5 miles of ocean frontage; and Fort Ross Historic Park, with about 1.5 miles of ocean frontage. Kruse Rhododendron Reserve is noted for its brilliant floral displays in the spring. Salt Point is especially interesting because, in spite of the spectacular surf break, it is one of the few areas in this section of the California coast where boats can be successfully launched. Fort Ross is the site of an old Russian fort established in 1812 as a base of operations for sea otter hunters ranging California waters. Most of the buildings have been reconstructed. The shoreline in this area is mainly composed of steep, rocky bluffs 40 to 50 feet in height. A small sandy beach is located at the mouth of Fort Ross Creek. State Highway No. 1 skirts within one-half mile of the shoreline throughout this reach. This reach is undergoing non-critical erosion.

The remaining 9 miles of the subregion's shoreline, from Fort Ross to the mouth of the Russian River, is even more rugged than the preceding reach. The coastline is somewhat less eroded, with mountains extending to the shoreline. State Highway No. 1 winds through the mountain slopes at elevations of 400 to 500 feet and at a distance no more than 1,000 feet from the shoreline. There is no access to the ocean and most of the area is uninhabited, unused, and privately owned. Critical erosion threatens State Highway No. 1 in two places, with the remainder of the reach being in a state of non-critical erosion.

LAND USE

Land use in the subregion's shoreline zone is predominantly in forest, public reserve, and unused or vacant lands. Urban use accounts for only about 14 miles, or about 4 percent of the total shoreline in the subregion. Coastal cities with over 1,000 population are Fort Bragg, Crescent City and Mendocino. Agricultural land, mostly pasture, accounts for about 87 miles, or 26 percent of the total shoreline. Forests and public reserves account for about 91 miles, or 27 percent of the total shoreline. The subregion has one mile of harbors and no military shoreline. The remaining 139 miles, or about 43 percent of the subregional shoreline, are in other uses as defined in the Regional Summary. Present land use patterns are summarized in the following tabulation, and are shown in Map 3.

County	Land use, in shoreline miles						
	Urban	Agri-culture	Military	Public Reserve	Harbors	Other	Total
Del Norte	4.0	1.9	0	21.7	0.1	17.8	45.5
Humboldt	0.5	9.2	0	46.3	0.5	64.8	121.3
Mendocino	1.0	56.3	0	14.3	0.4	48.3	120.3
Sonoma	8.8	19.6	0	8.3	0.0	8.0	44.7
Total	14.3	87.0	0	90.6	1.0	138.9	331.8

OWNERSHIP

In 1965, public ownership of shoreline land in the subregion totalled about 58 miles, or 18 percent of the subregion's shoreline. Most of the publicly-owned shoreline were in the categories of Federal reservations, State parks and beaches, county parks and beaches and special districts. Privately-owned shoreline, about 274 miles in all, consisted mainly of forest, grazing and unused lands.

In 1968, Congress authorized the creation of Redwood National Park, which, when acquisition is completed, will add about 22 miles of shoreline to public ownership. The shoreline boundary of the Redwood National Park

extends for about 37 miles from just south of Crescent City in Del Norte County to the vicinity of Stone Lagoon in Humboldt County. About 15 miles of the shoreline within the National Park is presently in State ownership, mostly in the form of State parks. Shoreline ownership in the subregion is summarized in the following tabulation and is shown on Map 3.

County	Land ownership, in shoreline miles					
	Public				Private	Total
	Federal	State	Local	Subtotal		
Del Norte	1.7	8.7	2.5	12.9	32.6	45.5
Humboldt	8.9	18.6	3.9	31.4	89.9	121.3
Mendocino	1.7	10.8	0	12.5	107.8	120.3
Sonoma	0	1.4	0	1.4	43.3	44.7
Total	12.3	39.5	6.4	58.2	273.6	331.8

RECREATIONAL SHORELINE

Of the 58 miles of publicly-owned shoreline in 1965, about 20 miles are classified as sandy beaches. The remaining public shoreline is composed of pebble and rocky beaches, and rocky shores and headlands or scenic shoreline. In addition, about 70 miles of the privately-owned shoreline are sandy beaches. Of the 20 miles of publicly-owned sandy beaches, about 14 miles are presently available for public use although access to some of these beaches is inadequate. The remaining public beaches are either inaccessible, undeveloped or within Federal reservations not presently open to the public. Due to unfavorable climate and exposure, all beaches in the subregion have been classified as non-swimming beaches. These beaches are generally used for fishing, SCUBA and skin diving, camping, picknicking, hiking and clam digging. About 32 miles of publicly-owned scenic shoreline are within existing public parks and available for public use. Existing public recreational shoreline available in 1965 is summarized in the following tabulation and is shown on Map 4.

County	Recreational and scenic shoreline, in miles		
	Swimming beach	Non-swimming beach	Scenic shoreline
Del Norte	0	0.5	9.5
Humboldt	0	8.5	14.2
Mendocino	0	5.0	6.9
Sonoma	0	0.0	1.4
Total	0	14.0	32.0

EROSION CHARACTERISTICS

Geologically speaking, the entire shoreline is eroding to some degree. However, for the purpose of this report, erosion characteristics have been classified into three categories--critical erosion, non-critical erosion, and non-eroding. These categories are defined in the Introduction. About 16 miles, or nearly 5 percent of the subregion's shoreline are considered to be eroding critically at the present, threatening urban properties, roads and highways. Non-critical erosion is occurring along about 238 miles, or 75 percent, of the shoreline. The remaining 78 miles of the shoreline in the subregion, mostly rocky cliffs and sand dunes, is non-eroding. In general, the erosion rates in the subregion are less severe than in the southerly subregions of the California Region, and have a maximum rate of about 1.5 feet per year. Erosion characteristics are summarized in the following tabulation and are shown on Map 5.

County	Erosion characteristics, in miles			
	Critical	Non-critical	Non-eroding	Total
Del Norte	2.4	25.1	18.0	45.5
Humboldt	1.4	63.7	56.2	121.3
Mendocino	11.3	105.4	3.6	120.3
Sonoma	0.4	44.3	0.0	44.7
Total	15.5	238.5	77.8	331.8

PROTECTIVE AND MITIGATIVE EFFORTS

General

The term "protection," as used in this report, refers to both structural and non-structural measures for the reduction of damages caused by shoreline erosion and tsunamis. Structural measures include such works as stabilization and beach fill, seawall and revetment, and periodic replenishment of existing beaches. Non-structural measures include zoning and regulating the use of the shoreline zone. The term "development" refers to the creation of new beaches and acquisition of scenic shoreline for public recreational use. Accomplishments relating to these activities are discussed in the following paragraphs.

Federal Projects

The authorities under which Federal beach erosion control and shore protection projects may be undertaken are described in the Regional Summary. No projects are authorized for construction in the North Coastal subregion. On 27 July 1946 the State Division of Beaches and Parks made formal application for a continuing cooperative Federal-State study of the entire Pacific Coast shoreline of the State of California. Included in this study were seven beaches in the North Coastal subregion, located between Point Delgada on the north and the mouth of the Russian River on the south. Studies of other beaches are continuing under other cooperative programs and other authorized Federal studies.

Non-Federal and Private Work

Shoreline protection works constructed by non-Federal interests have usually been improvisations that have been subject to substantial damage under the impact of severe storms. No substantial shoreline construction or maintenance activities by local interests along the shoreline of the North Coastal subregion are now in progress.

Non-structural Measures

The National Park Service has the authority for the development and establishment of scenic shoreline in the form of national parks and monuments, national recreation areas and national seashores. An example is the previously mentioned Redwood National Park, which will add about 22 miles of scenic shoreline for public use in the subregion when acquisition is completed. The State of California, through its Department of Parks and Recreation, also has the authority to acquire and develop scenic shoreline in the form of State parks. Practically all of the existing 32 miles of publicly-owned scenic shoreline in the subregion are within State parks.

Existing Federal authority with regard to beach development is limited to restoration of existing beaches that have been eroded and development of beaches incidental to shore protection projects. New beaches cannot be created where none are in existence, or in the absence of shore protection projects.

SHORELINE EROSION AND TSUNAMI DAMAGES, PRESENT CONDITIONS

Estimated shoreline erosion damages for the subregion were based on land use, rate of erosion and market value of shoreline properties that are subject to erosion damage. A detailed explanation of the method used for evaluating erosion damage is given in the Regional Summary.

The northern half of the California coast has a history of periodic damage from tsunamis (sea waves generated by seismic disturbances). The most destructive of these tsunamis occurred on 28 March 1964 with catastrophic results to the Crescent City area. Of the total damage of about $11.5 million occurring along the California coast north of Point Lobos in Monterey County, about $11.0 million were incurred in the Crescent City area. The remaining damages were widely distributed along the coast, including harbor facilities at Noyo River, San Francisco Bay and Santa Cruz. A wave height of about 26 feet at Crescent City caused inundation to about 530 acres of urban property. In addition to direct property loss, 8 lives were lost. A study is currently underway by the Corps of Engineers to determine the feasibility for protecting Crescent City from future tsunamis by means of a seawall. Estimated average annual tsunami damage to the Crescent City area was based on the relationship between historical and potential future damages, wave heights and expected frequency of occurrence.

The estimated average annual shoreline erosion damages for the subregion and tsunami damage to the Crescent City area are summarized in the following tabulation.

County	Average annual damage, in $1,000		
	Shoreline erosion	Tsunami	Total
Del Norte	$160	$270	$430
Humboldt	180	-	180
Mendocino	380	-	380
Sonoma	80	-	80
Total	$800	$270	$1,070

Future Needs in the Shoreline Zone

GENERAL

Future needs are evaluated in terms of reducing shoreline erosion damages and meeting the needs for recreational shoreline, including conservation of scenic shoreline. A detailed explanation of the method used to evaluate erosion damages, and the means whereby these damages could be reduced is contained in the Regional Summary. The Regional Summary also contains a detailed explanation of the methods used to evaluate the needs for recreational shoreline.

SHORELINE EROSION AND TSUNAMI DAMAGES, FUTURE CONDITIONS

The dollar values of future erosion and tsunami damages were estimated by applying economic growth factors based upon population projections and related economic indices to data for the base year (1965). It was assumed that, on the average, erosion rates would remain constant and that no erosion control projects would be constructed during the study period. The average annual shoreline erosion damage for the subregion and tsunami damage to the Crescent City area, under present and future conditions, are shown in the following tabulation.

County	Average annual erosion and tsunami damages, $1,000			
	1965	1980	2000	2020
Del Norte	430	650	1,470	3,030
Erosion	(160)	(230)	(500)	(1,030)
Tsunami	(270)	(420)	(970)	(2,000)
Humboldt	180	220	340	560
Mendocino	380	530	1,020	1,950
Sonoma	80	120	240	460
Subregion Total	1,070	1,520	3,070	6,000

SHORELINE RECREATION NEEDS

Projected needs for recreational beaches are based on projections of population and related economic factors for the North Coastal subregion and adjacent inland subregions. Due to unfavorable climate and exposure, future swimming beach needs for the subregion have been estimated at zero. Projected needs for conservation of

scenic shoreline are based upon the availability of the resource and recommendations of the National Park Service, the State of California and other governmental entities. The projected requirements for public recreational shoreline in the North Coastal subregion are shown in the following tabulation.

County	Cumulative Public Recreational Shoreline Needs, in Miles			
	1965	1980	2000	2020
Del Norte				
Swimming beach	0	0	0	0
Non-swimming beach	0.3	0.3	0.5	1.0
Scenic shoreline	9.5	24.7	30.0	30.0
Humboldt				
Swimming beach	0	0	0	0
Non-swimming beach	1.6	2.0	3.9	7.1
Scenic shoreline	14.2	25.0	35.5	35.5
Mendocino				
Swimming beach	0	0	0	0
Non-swimming beach	0.7	1.0	1.8	3.3
Scenic shoreline	6.9	13.4	20.5	25.5
Sonoma				
Swimming beach	0	0	0	0
Non-swimming beach	1.4	1.7	2.8	4.6
Scenic shoreline	1.4	4.9	10.0	10.0
SUBREGION TOTAL				
Swimming beach	0	0	0	0
Non-swimming beach	4.0	5.0	9.0	16.0
Scenic shoreline	32.0	68.0	96.0	101.0

Means to Satisfy Future Needs in the Shoreline Zone

GENERAL

The shoreline program for the subregion includes structural and non-structural protective measures to reduce potential future erosion damages, and the acquisition of scenic shoreline for public recreation use.

STRUCTURAL MEASURES

In the development of the structural phase of the shoreline program, emphasis was placed on those urban areas that are being threatened with critical erosion. Included in the nearly 16 miles of critical erosion in the subregion are numerous short reaches of roadways that, for the most part, are located on relatively high bluffs. In many of these reaches, relocation of the roadways is considered to be a better alternative than structural protection. Non-structural protection of eroding areas by means of shoreline management is discussed in subsequent paragraphs.

In addition to affording protection against erosion, some of the structural measures, namely stabilization works and beach replenishment, provide incidental beach areas for public recreation. These beach areas, together with available existing beaches, are adequate to meet the projected public beach requirements within the study period.

Table NC-1, at the end of this chapter, shows the projected scope, in miles, of potential shoreline protection projects for the subregion by time frames. Included in the 1966-1980 time [illegible]re are 1.6 miles of seawall for protection against tsunamis at [illegible]t City in Del Norte County.

NON-STRUCTURAL MEASURES

As shown in Table NC-1, the shoreline structural protection program for the subregion is minimal throughout the study period. Due to the unique scenic beauty and the wilderness character of much of the subregion's shoreline, it has been considered that emphasis should be placed on non-structural reduction of potential future erosion damages. A suitable non-structural measure would be zoning and regulating the use of the shoreline to restrict urban encroachment into the shoreline erosive zone.

Recently, proposals have been presented to the State Legislature that would establish State and regional commissions to deal with the conservation and development of the California coastal zone. The proposals include comprehensive and long range coastal zoning plans, and criteria and standards would be established for numerous environmental factors that could, if uncontrolled, detrimentally change or irreversibly modify the shoreline environment. Regulating land use to prevent structural encroachment into the erosive zone would come within these criteria and standards. However, such regional plan, by necessity, would be broad in scope and general in concept and probably would not contain detail inventory of the erosion characteristics of the shoreline. Therefore, the shoreline program presented herein includes a provision for a detailed study of the shoreline with respect to

its erosive character so that definitive guidelines may be established for the non-structural reduction of potential future erosion damages.

At the Federal level, several bills have been introduced in Congress that would establish a policy of Federal participation with regard to the conservation and development of the Nation's coastal resources.

ACQUISITION OF RECREATIONAL SHORELINE

The North Coastal subregion contains 32 miles of the 76 miles of existing (1965) scenic mainland coastal shoreline in the California Region that are available for public recreational use. Additional acquisition of 36 miles in the 1966-1980 time frame, 28 miles in the 1981-2000 time frame, and 5 miles in the 2001-2020 time frame are included in the shoreline program. By 2020, if the acquisition program is implemented, the subregion will contain about 101 miles of scenic shoreline, or nearly one-half of the 218 miles of mainland coastal scenic shoreline proposed in the total program for the region. The creation of the Redwood National Park in 1968 and the King Range Conservation Area in 1970 indicates the national concern for acquiring and preserving this type of shoreline for future public recreational use. Acquisition will provide complete public control and management of such areas and result in substantial reductions in shoreline erosion damages.

Publicly-owned non-swimming beaches in the North Coastal subregion now approximates the 16 miles of projected beach requirements in 2020 for the subregion, though some of the beaches are not located near population centers and others are not readily accessible. However, it is expected that recreational beach requirements for the subregion would be met during the study period by improvement of access to existing beaches, and creation of additional beach areas in connection with shore protection projects.

Of the total scenic shoreline needs of 101 miles in 2020 for the subregion, 32 miles are presently (1965) in public ownership. To satisfy future needs, 36 miles would need to be acquired during the 1966-1980 time frame, 28 miles during the 1981-2000 time frame and 5 miles during the 2001-2020 time frame. Acquisition for the Redwood National Park, authorized in 1968, will contribute about 22 miles of scenic shoreline toward the 1965-1980 requirements. About 15 miles of the total 37 miles of shoreline within the Park boundary are already in the public ownership and available for public use in 1965. Table NC-3 summarizes the extent of available public recreational shoreline in the subregion by types and by time frames, if the program is implemented.

EFFECTIVENESS OF THE SHORELINE PROGRAM

As indicated in the tabulation on page NC-18, average annual erosion damages for the North Coastal subregion and tsunami damage for the Crescent City area will increase from about $1.1 million in 1965 to $1.5 million by 1980, $3.1 million by 2000, and $6.0 million by 2020, if no measures to prevent these damages are implemented after 1965. If the shoreline program presented herein is fully implemented, the average annual residual shoreline erosion and tsunami damages will decrease from about $1.1 million in 1965 to $0.9 million by 1980, $0.8 million by 2000, and $0.5 million by 2020, as shown in Table NC-2. The overall reduction of the potential average annual shoreline erosion and tsunami damages due to full implementation of the shoreline program amounts to about $0.6 million by 1980, $2.3 million by 2000, and $5.5 million by 2020. Table NC-2 summarizes the effectiveness of the shoreline protection program in reducing shoreline erosion damage in the subregion and tsunami damage in the Crescent City area.

Publicly-owned recreational shoreline in the North Coastal subregion will increase from 48 shoreline miles to 117 shoreline miles to meet non-swimming beach and scenic shoreline demands during the study period. The overall total of 16 miles of non-swimming beach presently in public ownership will be adequate to meet requirements during the study period. The overall total of 101 miles of scenic shoreline will conserve the most significant scenic shoreline in the subregion. Table NC-3 summarizes the extent of shoreline available by types of shoreline and by time frames, if the program is implemented.

Implementation

BASES FOR COST ESTIMATES

Estimates of costs for the shoreline protection in the North Coastal subregion were based to a large extent on data from available reports and current studies, adjusted to reflect particular site conditions. Reconnaissance-scope estimates were made where existing data were not available. In general, unit costs were developed for each subregion for structural measures and applied to sites with similar characteristics. Costs for scenic shoreline were based on prevailing land values for the particular area. The extent of each scenic shoreline site was determined by its scenic value and topography. Costs associated with non-structural measures to reduce potential shoreline erosion damages were based on the estimated cost studies needed to establish necessary guidelines for regulation of land use within the shoreline erosive zone.

ESTIMATED SHORELINE PROGRAM COSTS

The estimated installation costs for the shoreline protection program in the North Coastal subregion amount to about $11.4 million for the 1966-1980 time frame, $9.7 million for the 1981-2000 time frame, and $8.4 million for the 2001-2020 time frame. These cost estimates do not include expenditures for access roads, or parking and sanitary facilities, which are included in Appendix XII: Recreation, under the general categories of development and acquisition costs for recreation land Classes I and II. Cumulative annual maintenance costs amount to $130,000, $260,000, and $440,000 for the respective time frames. All maintenance costs are the responsibility of non-Federal interests, with the exception of those connected with scenic shoreline within the Redwood National Park in Del Norte and Humboldt Counties.

Table NC-4 summarizes the shoreline protection program costs for the North Coastal subregion.

TABLE NC-1
NORTH COASTAL SUBREGION
Potential Projects, in Miles

Item	1966-1980	1981-2000	2001-2020	Program Total
Del Norte County				
Beach Stabilization	0	1.0	0	1.0
Seawalls	2.0	0	1.0	3.0
Beach Replenishment	0	0	1.0	1.0
Beach Development	0	0	0	0
Humboldt County				
Beach Stabilization	0.5	0	0.5	1.0
Seawalls	0	0	0	0
Beach Replenishment	0	0	0	0
Beach Development	0	0	0	0
Mendocino County				
Beach Stabilization	0.5	0	0	0.5
Seawalls	0	1.0	1.0	2.0
Beach Replenishment	0	0	1.0	1.0
Beach Development	0	0	0	0
Sonoma County				
Beach Stabilization	0	0	0.5	0.5
Seawalls	0	0	0	0
Beach Replenishment	0	0	0	0
Beach Development	0	0	0	0
SUBREGION TOTAL				
Beach Stabilization	1.0	1.0	1.0	3.0
Seawalls	2.0	1.0	2.0	5.0
Beach Replenishment	0	0	2.0	2.0
Beach Development	0	0	0	0

TABLE NC-2
NORTH COASTAL SUBREGION
Estimated Average Annual Shoreline Erosion Damages and Damage Reduction through Shoreline Program, in $1,000 (1965 prices)

Item	Del Norte County	Humboldt County	Mendocino County	Sonoma County	Subregion
Average annual damages, 1965	430	180	380	80	1,070
Average annual damage by 1980 with no shoreline program	650	220	530	120	1,520
Reduction in damage with 1966 to 1980 shoreline program					
Structural measures	260	50	50	0	360
Non-structural measures	90	70	120	30	310
Program total	350	120	170	30	670
Residual annual damage in 1980	300	100	360	90	850
Average annual damage by 2000 with no shoreline program after 1980	540	180	640	160	1,520
Reduction in damage with 1981 to 2000 shoreline program					
Structural measures	155	0	155	0	310
Non-structural measures	140	90	140	70	440
Program total	295	90	295	70	750
Residual annual damage in 2000	245	90	345	90	770
Average annual damage by 2020 with no shoreline program after 2000	370	140	520	140	1,170
Reduction in damage with 2001 to 2020 shoreline program					
Structural measures	155	65	155	65	440
Non-structural measures	103	20	50	17	190
Program total	258	85	205	82	630
Residual annual damage in 2020	112	55	315	58	540
Estimated annual damage in 2020 with no shoreline program after 1965	3,030	560	1,950	460	6,000
Total reduction in annual damage due to 1966 to 2020 shoreline program	2,918	505	1,635	402	5,460

TABLE NC-3
NORTH COASTAL SUBREGION
Estimated Recreational Shoreline Needed, and Recreational Shoreline Made Available by the Program, in Miles

Item	Del Norte County			Humboldt County			Mendocino County			Sonoma County			Total subregion		
	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline
Available in 1965	0	0.5	9.5	0	8.5	14.2	0	5.0	6.9	0	0	1.4	0	14.0	32.0
Needed by 1980	0	0.3	-	0	2.0	-	0	1.0	-	0	1.7	-	0	5.0	-
Deficiency (-) or surplus (+)	0	+0.2	-	0	+6.5	-	0	+4.0	-	0	-1.7	-	0	+9.0	-
1966-1980 program supply	0	1.0	15.2	0	0.5	10.8	0	0.5	6.5	0	1.0	3.5	0	3.0	36.0
Available in 1980 with program	0	1.5	24.7	0	9.0	25.0	0	5.5	13.4	0	1.0	4.9	0	17.0	68.0
Needed by 2000	0	0.5	-	0	3.9	-	0	1.8	-	0	2.8	-	0	9.0	-
Deficiency (-) or surplus (+)	0	+1.0	-	0	+5.1	-	0	+3.7	-	0	-1.8	-	0	+8.0	-
1981-2000 program supply	0	1.0	5.3	0	0	10.5	0	0	7.1	0	0	5.1	0	1.0	28.0
Available in 2000 with program	0	2.5	30.0	0	9.0	35.5	0	5.5	20.5	0	1.0	10.0	0	18.0	96.0
Needed by 2020	0	1.0	-	0	7.1	-	0	3.3	-	0	4.6	-	0	16.0	-
Deficiency (-) or surplus (+)	0	+1.5	-	0	+1.9	-	0	+2.2	-	0	-3.6	-	0	+2.0	-
2001-2020 program supply	0	0	0	0	0.5	0	0	0	5.0	0	0.5	0	0	1.0	5.0
Available in 2020 with program	0	2.5	30.0	0	9.5	35.5	0	5.5	25.5	0	1.5	10.0	0	19.0	101.0
Needed by 2020	0	1.0	-	0	7.1	-	0	3.3	-	0	4.6	-	0	16.0	-
Deficiency (-) or surplus (+) at end of program	0	+1.5	-	0	+2.4	-	0	+2.2	-	0	-3.1	-	0	+3.0	-

TABLE NC-4

NORTH COASTAL SUBREGION

Estimated Shoreline Program Costs, in $1,000 (1965 prices)

1966-1980 PROGRAM

Item	Del Norte County	Humboldt County	Mendocino County	Sonoma County	Subregion Total
STRUCTURAL MEASURES:					
Installation costs					
Federal	1,150	700	700	0	2,550
Non-Federal	650	700	700	0	2,050
Subtotal	1,800	1,400	1,400	0	4,600
Annual OM & R					
Federal	0	0	0	0	0
Non-Federal	18	21	21	0	60
Subtotal	18	21	21	0	60
NON-STRUCTURAL MEASURES:					
Installation costs					
Federal	2,300	1,700	0	0	4,000
Non-Federal	540	350	1,280	660	2,830
Subtotal	2,840	2,050	1,280	660	6,830
Annual OM & R					
Federal	24	19	0	0	43
Non-Federal	6	3	12	6	27
Subtotal	30	22	12	6	70
1966-1980 PROGRAM					
Federal	3,450	2,400	700	0	6,550
Non-Federal	1,190	1,050	1,980	660	4,880
Total	4,640	3,450	2,680	660	11,430
Annual OM & R	48	43	33	6	130

Continued

TABLE NC-4--Continued

NORTH COASTAL SUBREGION

Estimated Shoreline Program Costs, in $1,000 (1965 prices)

1981-2000 PROGRAM

Item	Del Norte County	Humboldt County	Mendocino County	Sonoma County	Subregion Total
STRUCTURAL MEASURES:					
Installation costs					
Federal	1,600	0	600	0	2,200
Non-Federal	1,600	0	600	0	2,200
Subtotal	3,200	0	1,200	0	4,400
Annual OM & R					
Federal	0	0	0	0	0
Non-Federal	65	0	15	0	80
Subtotal	65	0	15	0	80
NON-STRUCTURAL MEASURES:					
Installation costs					
Federal	0	0	0	0	0
Non-Federal	1,000	2,000	1,390	940	5,330
Subtotal	1,000	2,000	1,390	940	5,330
Annual OM & R					
Federal	0	0	0	0	0
Non-Federal	10	20	10	10	50
Subtotal	10	20	10	10	50
1981-2000 PROGRAM					
Federal	1,600	0	600	0	2,200
Non-Federal	2,600	2,000	1,990	940	7,530
Total	4,200	2,000	2,590	940	9,730
Annual OM & R	75	20	25	10	130

Continued

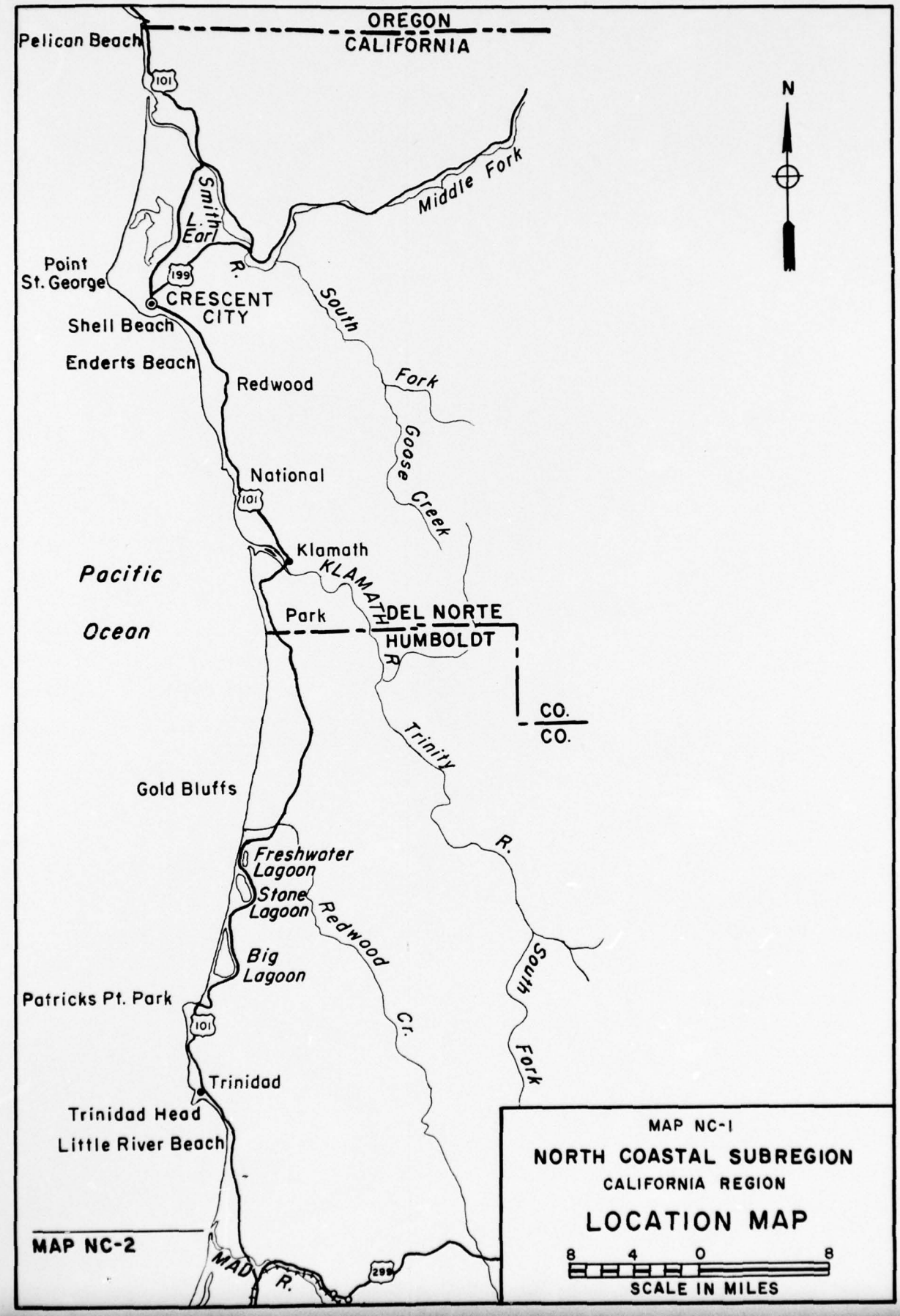
TABLE NC-4--Continued

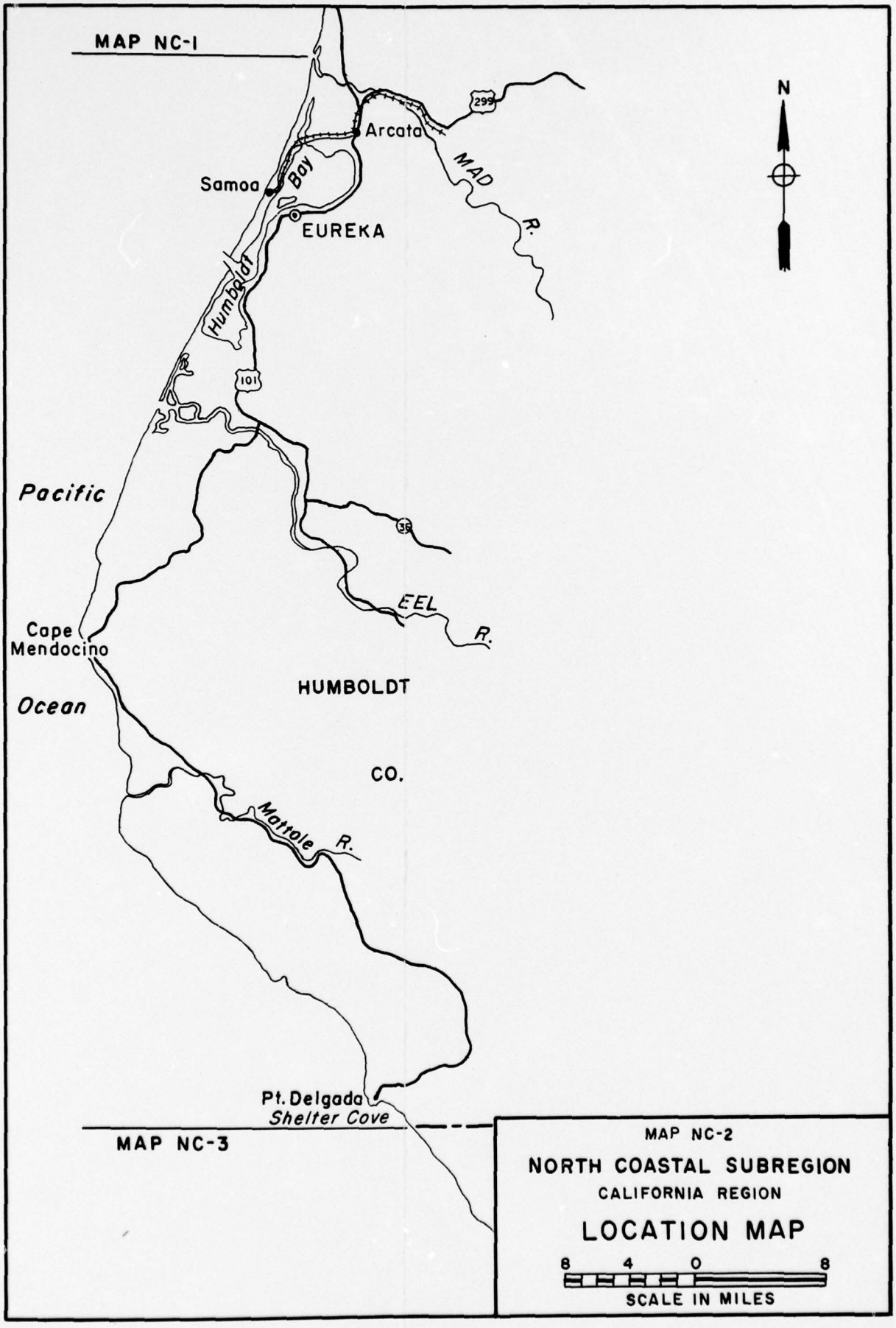
NORTH COASTAL SUBREGION

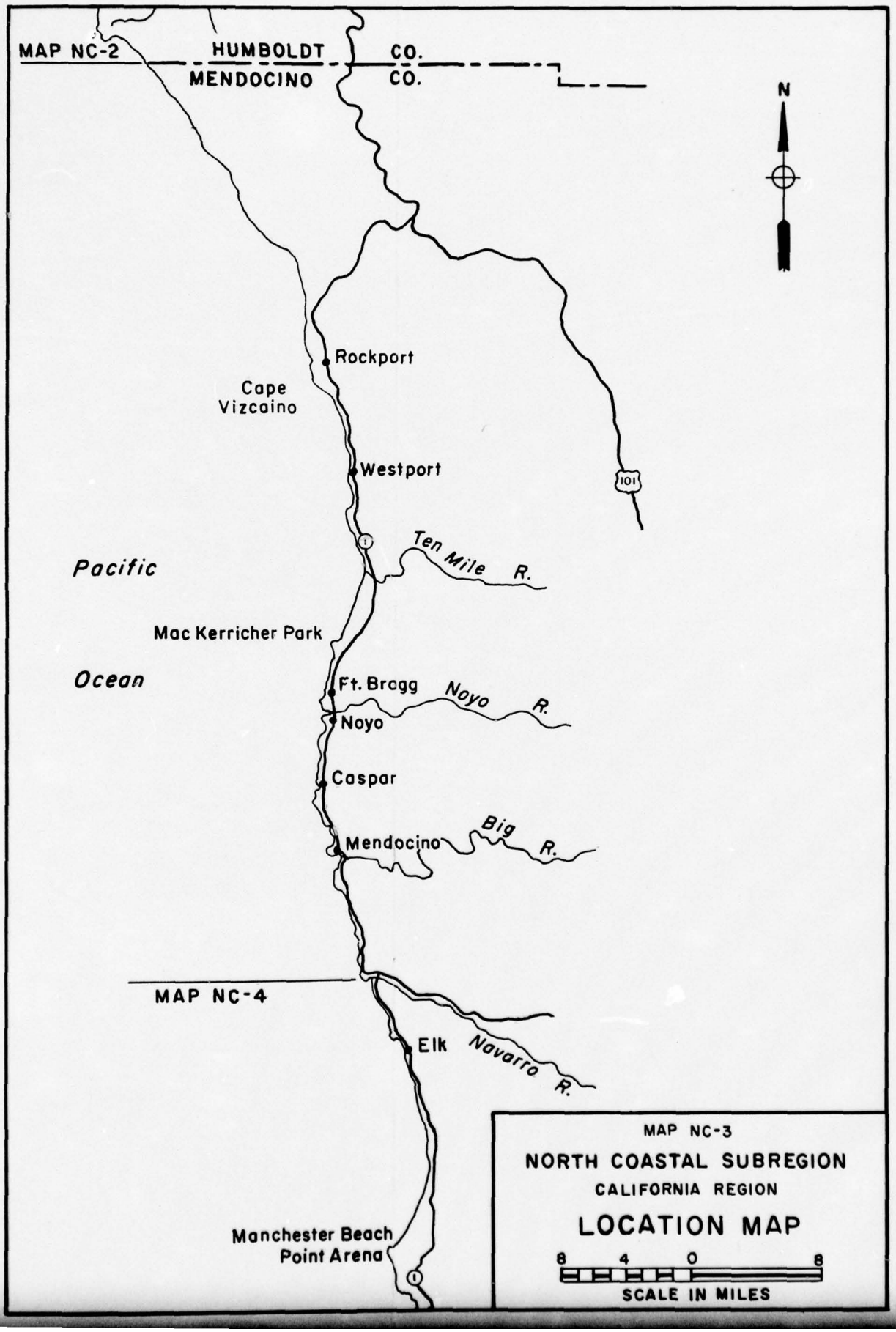
Estimated Shoreline Program Costs, in $1,000 (1965 prices)

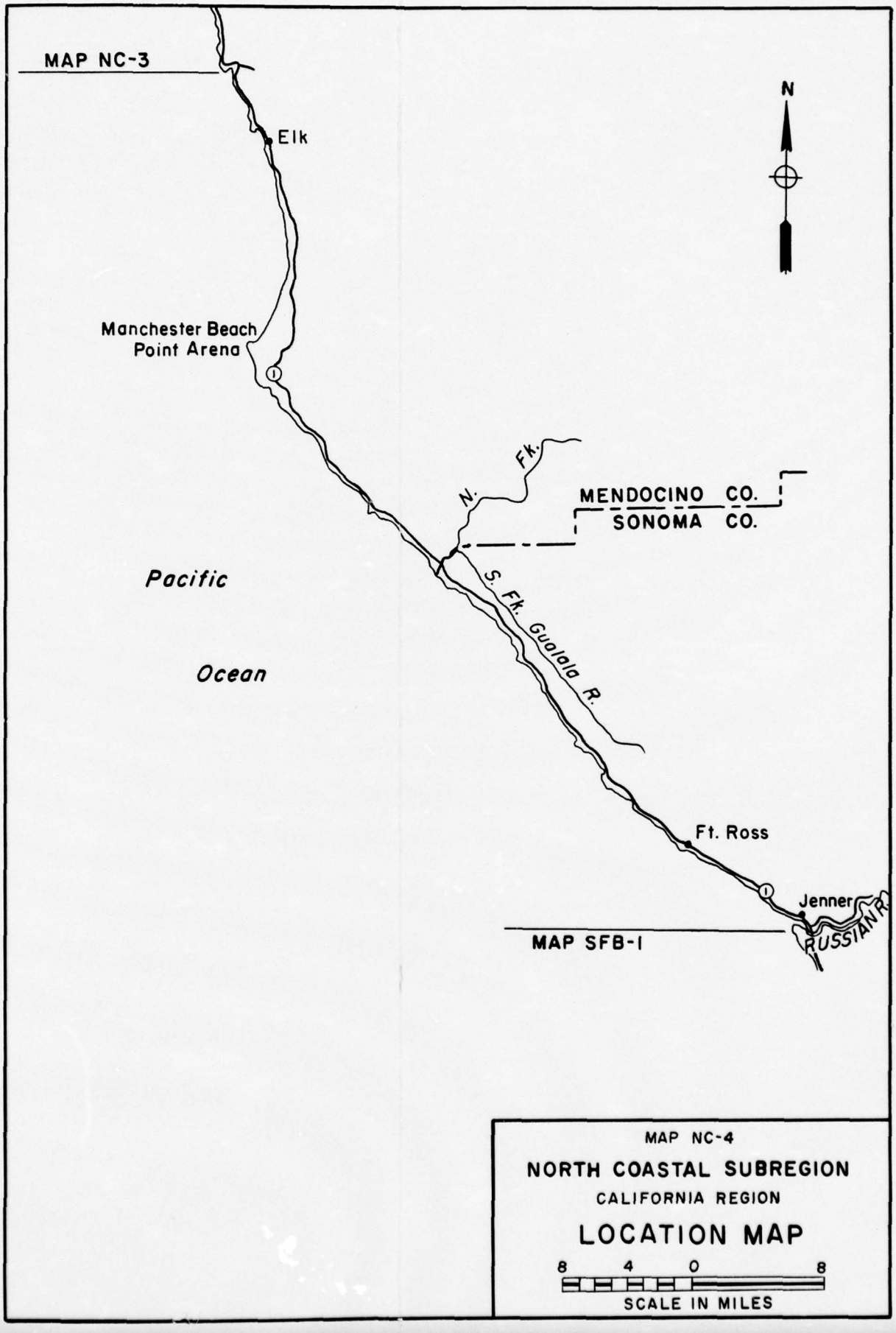
2001-2020 PROGRAM

Item	Del Norte County	Humboldt County	Mendocino County	Sonoma County	Subregion Total
STRUCTURAL MEASURES:					
Installation costs					
Federal	1,000	800	1,000	800	3,600
Non-Federal	1,000	800	1,000	800	3,600
Subtotal	2,000	1,600	2,000	1,600	7,200
Annual OM & R					
Federal	0	0	0	0	0
Non-Federal	52	33	53	32	170
Subtotal	52	33	53	32	170
NON-STRUCTURAL MEASURES:					
Installation costs					
Federal	0	0	0	0	0
Non-Federal	50	120	1,020	40	1,230
Subtotal	50	120	1,020	40	1,230
Annual OM & R					
Federal	0	0	0	0	0
Non-Federal	0	0	10	0	10
Subtotal	0	0	10	0	10
2001-2020 PROGRAM					
Federal	1,000	800	1,000	800	3,600
Non-Federal	1,050	920	2,020	840	4,830
Total	2,050	1,720	3,020	1,640	8,430
Annual OM & R	52	33	63	32	180

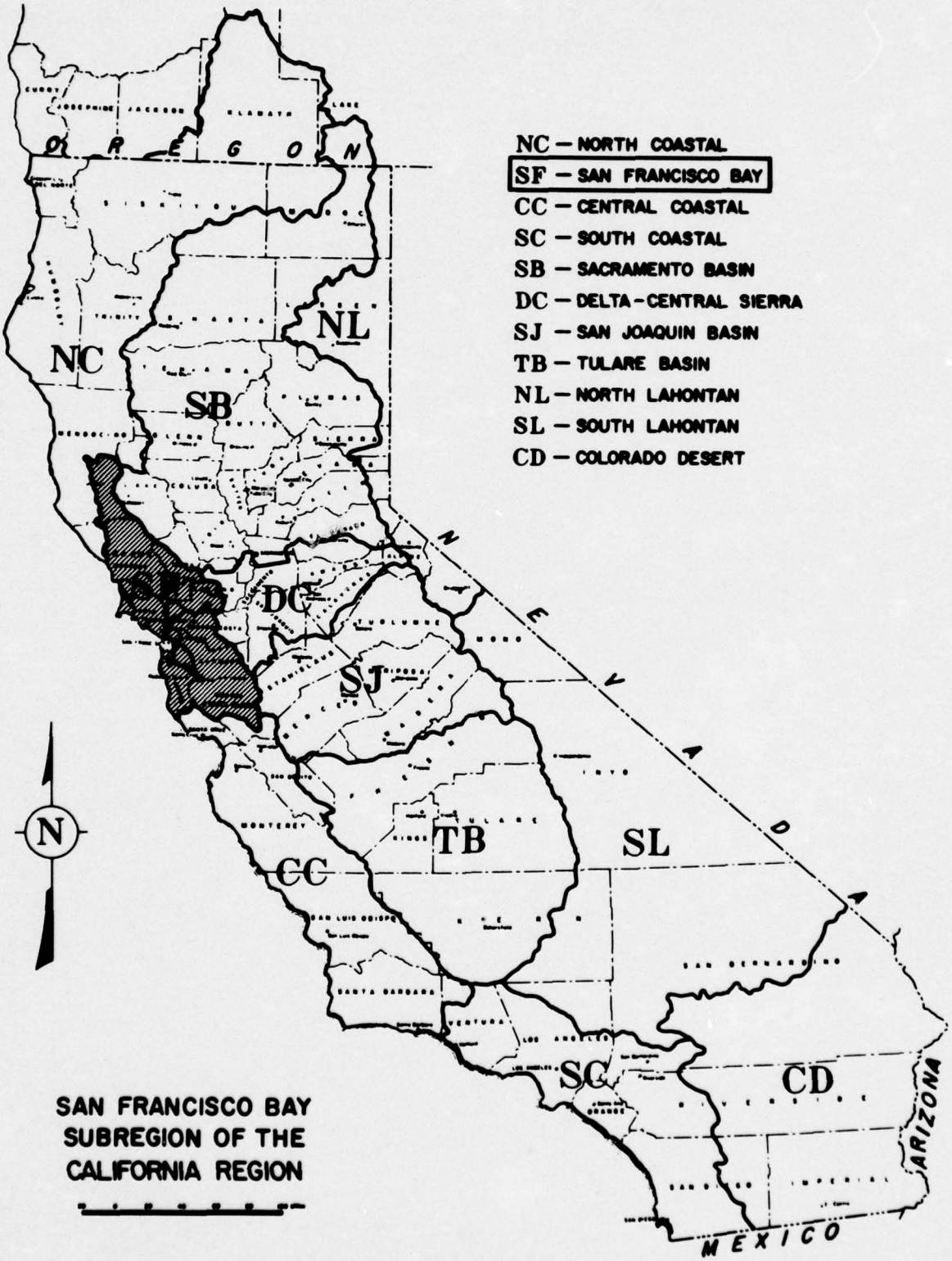

OREGON
CALIFORNIA
Pelican Beach
101
N
Middle Fork
Smith
L. Earl
R.
199
Point
St. George
CRESCENT
CITY
Shell Beach
Enderts Beach
Redwood
South
Fork
Goose Creek
National
101
Klamath
KLAMATH
R.
Pacific
Ocean
Park
DEL NORTE
HUMBOLDT
CO.
CO.
Trinity
R.
Gold Bluffs
Freshwater
Lagoon
Stone
Lagoon
Redwood
Cr.
South
Fork
Big
Lagoon
Patricks Pt. Park
101
Trinidad
Trinidad Head
Little River Beach
MAP NC-2
MAD
R.
299
MAP NC-1
NORTH COASTAL SUBREGION
CALIFORNIA REGION
LOCATION MAP
8 4 0 8
SCALE IN MILES


MAP NC-1
N
299
Arcata
MAD R.
Samoa
Bay
EUREKA
Humboldt
101
Pacific
Ocean
Cape Mendocino
HUMBOLDT
CO.
EEL R.
Mattole R.
Pt. Delgada
Shelter Cove
MAP NC-3
MAP NC-2
NORTH COASTAL SUBREGION
CALIFORNIA REGION
LOCATION MAP
8 4 0 8
SCALE IN MILES


MAP NC-2
HUMBOLDT CO.
MENDOCINO CO.
N
Rockport
Cape Vizcaino
Westport
101
Pacific
Ocean
Ten Mile R.
Mac Kerricher Park
Ft. Bragg
Noyo R.
Noyo
Caspar
Mendocino
Big R.
MAP NC-4
Elk
Navarro R.
Manchester Beach
Point Arena
MAP NC-3
NORTH COASTAL SUBREGION
CALIFORNIA REGION
LOCATION MAP
8 4 0 8
SCALE IN MILES


MAP NC-3
N
Elk
Manchester Beach
Point Arena
1
N. Fk.
MENDOCINO CO.
SONOMA CO.
Pacific
Ocean
S. Fk. Gualala R.
Ft. Ross
1
Jenner
RUSSIAN R.
MAP SFB-1
MAP NC-4
NORTH COASTAL SUBREGION
CALIFORNIA REGION
LOCATION MAP
8 4 0 8
SCALE IN MILES

SAN FRANCISCO BAY SUBREGION



SAN FRANCISCO BAY SUBREGION OF THE CALIFORNIA REGION

SAN FRANCISCO BAY SUBREGION

Description of the Subregion

PHYSICAL CHARACTERISTICS

The San Francisco Bay subregion encompasses an area of 6,112 square miles, and includes all of San Francisco, San Mateo and Marin counties, nearly all of Sonoma County and substantial portions of Alameda, Contra Costa, Napa, Santa Clara and Solano counties. Each of the nine counties fronts on the San Francisco Bay shoreline. In addition, Sonoma and Marin counties front on the coastal shoreline north of the Golden Gate; and San Francisco and San Mateo counties front on the coastal shoreline south of the Golden Gate. Of a total shoreline length of about 430 miles, approximately 280 miles front on San Francisco Bay and 150 miles are coastal shoreline. The opposite index map shows the nine subregion counties and the relationship of the San Francisco Bay subregion to other subregions of the California Region.

The subregion is of varied topography and includes rugged mountainous terrain, rolling hills, high mountain peaks, numerous small valleys and streams, large fertile valleys and extensive tidelands and marshlands. The subregion is interrupted by the San Francisco Bay System, which drains the Sacramento and San Joaquin River Basins through the Golden Gate into the Pacific Ocean. The abrupt changes in elevation and character of the shoreline areas create numerous scenic view and recreation sites and beaches within the subregion.

The continental shelf off the subregion is variable in extent. The shelf is approximately 10 miles wide in the vicinity of Point Ano Nuevo; about 30 miles wide, including the Farallon Islands, at the Golden Gate; about 20 miles wide at Point Reyes; and about 10 miles wide at the mouth of Russian River. Numerous submarine canyons extend from deep water through the continental shelf.

CLIMATE AND EXPOSURE

The subregion has a temperate climate and the coastal areas are characterized by mild summers and moderate winters. Annual temperatures average about 57° F along the coastal areas of the subregion. In the base year of 1965, maximum temperatures varied from 102° at Santa Cruz, 90° F at San Francisco, 87° F at Oakland to 92° F at Point Arena. Minimum temperatures ranged from 25° at Santa Cruz to 35° F at San Francisco, and 32° F at Oakland.

Ocean temperatures of the subregion range in the low 50's during the wintertime and bay water temperatures are comparable. During midsummer months, ocean temperatures rise to the high 50's and water temperatures in the bay rise to the high 60's and low 70's. Offshore waters along the coast are too cold for swimming during most of the year, although a limited amount of swimming activity occurs during midsummer months. Warmer waters within the bay are suitable for swimming during the summer season; however, pollution of bay waters has become an increasing concern during recent years and has deterred full utilization of bay waters for beach activities.

Rainfall varies from an annual average of about 20 inches in the south to 60 inches in the north, and is subject to substantial variation due to the influence of local topography.

Storms of severe intensity occur with moderate frequency during the 5-month winter storm season from November to April, and are generally of greater magnitude and frequency than storms in the southerly subregions, and of lesser magnitude and frequency than storms of the northerly subregions. Due to the existence of a "semi-permanent high" off the Pacific Coast during the summer months, summer storms are infrequent. Diurnal advective fogs are generated by cooling of warmer offshore air masses by the sea during the summer season May to September. Prevailing northwesterly winds move the fog banks landward toward sundown and may blanket the coastline and inshore areas with heavy dense fogs that persist until dissipated by solar energy the following day.

POPULATION DISTRIBUTION

The San Francisco Bay subregion had an estimated population of 4,061,000, approximately 22.4 percent of the total 18,106,000 population of the California Region in 1965. The concentration of population in the San Francisco Bay subregion creates a continuing demand for local one-day recreational facilities within the subregion and in the nearby Central Coastal subregion.

The subregional population has been projected to increase to 5,697,000 by 1980; 8,421,000 by 2000; and 11,225,000 by 2020. The 2020 subregional population represents about 20.4 percent of the projected regional population of 54,941,000.

ECONOMY

The economy of the subregion is primarily commercial and industrial. Major industries are manufacturing establishments and petroleum refineries. Agriculture is of secondary importance. Manufacturing, wholesale and retail trade and services comprise about 65 percent of total subregion employment. Principal manufactured products are fabricated metals,

and non-electrical and electrical machinery. Finance, insurance and real estate activities occupy approximately 6 percent of the subregion's working population and the remainder are engaged in government services, agriculture and other activities. Subregion port facilities of the San Francisco Bay complex handled about 45,000,000 tons of commercial shipping in the base year of 1965, 50 percent of the total commerce of the California Region. A commercial fishing fleet of 1,000 vessels use San Francisco Bay facilities as their home port and about 12,000 recreational boats are berthed in subregion waters.

TRANSPORTATION

The subregion has an excellent freeway system which provides ready access to most shoreline areas from all parts of the subregion. State Highway No. 1 provides access to the shoreline areas along the coast from Point Ano Nuevo to the mouth of the Russian River. The Southern Pacific Railroad, Santa Fe Railroad and the Northwest Pacific Railroad provide passenger and freight transportation service between points within the San Francisco Bay subregion and to destinations from coast to coast as a part of an integrated national system of railroads that covers the North American continent. Major commercial airports are located at San Francisco and Oakland, and additional airport installations are located at Napa County, Concord, Hayward, San Jose, and Santa Rosa. Direct flights to major airports throughout the world are available at San Francisco and Oakland airports. Bus service is available within the subregion and to destinations throughout the United States.

Existing Conditions in the Shoreline Zone

GENERAL

The study area covered by this appendix is limited to the shoreline zones of the regional coastline and San Francisco Bay. The coastal shoreline zone is defined as the active erosive zone affected within the study period. This narrow zone is generally limited to a width not in excess of 500 feet. The San Francisco Bay shoreline is similarly defined although erosive forces are less substantial; however, the 500-foot width is used for uniformity within the subregion.

The subregional coastal shoreline includes precipitous mountains, steep eroded seacliffs, terraced and rolling hills, river valleys, bays, estuaries, sandspit lagoons and rocky and sandy beaches. Beach cover varies from fine-grained sands to pebbles and cobbles. Beach formations include coves, sheltered bights, and unsheltered expanses of exposed beach. Offshore rocks occur in the more rugged shoreline areas.

The San Francisco Bay shoreline includes steep and rolling mountains, rolling hills, extensive marshlands and tidelands, sandy beach areas, lagoons and small bays. About one half of the shoreline frontage is reclaimed land protected by revetments and earth levees. Shoreline characteristics are shown in Map 2.

DESCRIPTION OF COASTAL SHORELINE

General

Of the total of 152 miles of coastal shoreline, about 24 miles or 16 percent is considered to be non-eroding or stable. The remaining 128 miles is actively eroding, and about 12 miles of shoreline is subject to critical erosion that threatens several highly urbanized areas of San Francisco County and the northerly shoreline of San Mateo County. The observed and projected rates of erosion range upward to as much as 4 feet per year. The following paragraphs describe the coastal shoreline topography and other characteristics and problems by counties, from north to south. Major locations are shown on Maps SFB-1 through SFB-3, at the end of this chapter.

Sonoma County

Sonoma County has a coastal shoreline length of about 18 miles within the San Francisco Bay subregion, or about 12 percent of the 152-mile total. From the mouth of the Russian River to Bodega Head, a reach of about 11 miles, the shoreline includes sandy to pebbly beaches and rocky, scenic shoreline. This reach has been designated as Sonoma Coast State Beach; State Highway No. 1 is within 1 mile of the coastline. Numerous small beaches are located in this scenic reach, including Goat Rock Beach, Shell Beach, Wright Beach, Portugese Beach, Arch Rock Beach and Salmon Creek Beach. These areas are suitable for picnicking, camping, fishing, and abalone fishing. Land use between the State Highway and the shoreline is predominately recreational and wildlife reserves. A small residential community is located at Ocean View near Duncan Point. Erosion in this vicinity is classified as critical. The extent of erosion in the remainder of this reach varies from none to slow non-critical erosion.

Bodega Head is a 2.5-mile-long peninsula, with about 6 miles of shoreline, that bounds Bodega Harbor on the west. The shoreline consists of narrow sandy beach, and, at the southwest end of the peninsula, rocky shore and many rocks offshore. Uplands rise to a height of about 150 feet and consist of partially stabilized to shifting sand dunes and hummocks. The southwest portion of the peninsula is covered with grass. Horseshoe Cove and other portions of the shoreline are noted for marine biology and scenic qualities. Bodega Bay State Park and Doran Beach County Park are in this reach. Bodega Harbor has extensive mudflats with clams and associated invertebrate marine life.

It is a valuable habitat for waterfowl, shore birds, marine birds and many songbirds. Grazing is the dominant land use. A small residential development is located on the easterly shore of Bodega Harbor. Erosion in this vicinity is slight. A University of California Marine Biology Research Station is located at Bodega Head.

The 2-mile reach from Doran Beach County Park southerly to the mouth of Estero Americano, at the Sonoma-Marin county boundary line, forms a part of the easterly shore of Bodega Bay. The terrain merges from sandy beach to steep, rugged sea cliffs and offshore rocks. The land is almost entirely undeveloped. There is little erosion in this reach.

Marin County

Marin County has a coastal shoreline length of about 70 miles or about 46 percent of the subregion's total ocean shoreline. From the mouth of Estero Americano to Tomales Bluff, at the tip of Tomales Point, is a distance of 7 miles; the shoreline is very rugged with steep headlands 50 to 70 feet high and numerous offshore rocks. Between Dillon Beach and Sand Point, at the mouth of Tomales Bay, a broad, sandy beach fronts inshore windblown sand dunes that range in height from 30 to 40 feet. Tomales Bay is a long, narrow inlet about 15 miles long and 1 mile wide. Tomales Point forms the seaward portion of the bay's westerly shore. Several small communities and Tomales Bay State Park are located along the bay shoreline. The shoreline along the westerly side of the mouth of Tomales Bay includes the extremely rocky and rugged shoreline of Tomales Point and a small, narrow beach area that merges into the numerous offshore rocks in the vicinity of Tomales Bluff. Except for the town of Dillon Beach, a small, residential beach development, this reach is otherwise undeveloped. State Highway No. 1 and local county roads provide access to the shoreline. State Highway No. 1 extends along the east shore of Tomales Bay for a distance of about 10 miles to Point Reyes Station. The shoreline extends about 4 miles southerly from Tomales Point to McClures Beach, and then curves more southwesterly into the Point Reyes Beach, which extends to the Point Reyes Lighthouse at Point Reyes, about 15 miles distant. Between Tomales Point and McClures Beach, the shoreline is rugged with numerous offshore rocks. McClures Beach is about 2,500 feet long, has an average width of about 200 feet and is bounded on the north and south by small, rocky headlands. Beach sand is very fine to medium grained. There is no indication of a beach erosion problem at this site. Terrace deposits of silty sand can be seen in some canyons behind the beach. The area is undeveloped; access is available from a local road. From McClures Beach to the Point Reyes Lighthouse, the shoreline is sandy beach for the most part, with inshore windblown sand dunes that reach heights of 100 feet or more. There is no erosion problem. The area is entirely undeveloped; access to the shoreline is limited except a county road serving the U.S. Coast Guard reservation and dairy farms on the Point Reyes Peninsula.

Point Reyes National Seashore is roughly triangular. The shoreline reach from Tomales Point to Point Reyes, and the reach from Point Reyes to the vicinity of Bolinas form two sides of the triangle. The third side is formed by a relatively straignt boundary line that runs southeasterly from Tomales Bluff along the westerly shore of Tomales Bay, through the town of Point Reyes Station, and then to the vicinity of Bolinas. The National Seashore is under jurisdiction of the National Park Service and will be managed as a wildlife preserve and recreation area. Commercial fishing activities will probably continue, and there is a possibility that a small-craft harbor of refuge may be developed near Point Reyes, although marina-type developments are not contemplated. No residential or commercial developments are planned. The area within Point Reyes Peninsula contains about 28,000 acres, including about 45 miles of shoreline. The upland consists of sand dunes; vegetation varies from grassland to chaparral to magnificent fir and pine forests. In addition to Drakes Estero, there are nine inland fresh-water lakes and Abbotts Lagoon, with an area of several hundred acres, several fresh and salt-water marshes, and an interesting variety of birds and mammals. The transition from the seashore area to the forest-covered Inverness Ridge, about 2 miles inshore, provides a combination of scenic, recreational, and biologic interests that can be found nowhere else in this country as near to a large center of population.

From Point Reyes Lighthouse to Chimney Rock, a distance of about 4 miles, the blunt end of the point Reyes Peninsula is a steep seacliff that lies perpendicular to the peninsula axis. Numerous offshore rocks are located in this reach. Erosion is not critical. Between Chimney Rock and Bolinas, the shoreline is crescent-shaped and forms Drakes Bay, which faces to the south. The shoreline is variable in character and includes steep, coastal bluffs, offshore rocks, wave-swept caves, sandy beaches, and a sandspit 3 miles in length. North of Chimney Rock, a 7-mile stretch of beach, averaging 300 feet in width, forms the westerly and northerly shoreline of Drakes Bay. Beach cover varies from fine-grained sand to well-rounded sandstone cobbles and boulders. Drakes Beach is accessible by county road, and a small bathhouse and picnic facilities have been installed. Future seashore planning includes scenic overlooks, beach and upland hiking trails, and the opportunity for ocean swimming, fresh water and surf fishing, camping, picnicking and auto touring. Drakes Estero, just to the northeast of Drakes Beach, includes 28 miles of shoreline fronting an interior lagoon, the easterly portion of which is formed by the 3-mile-long Limantour sandspit. Between Drakes Estero and Double Point, near Bolinas, there is no improved access to the shoreline and the area is undeveloped. Erosion damage varies from accretion in the vicinity of Drakes Estero, due to the characteristic headland-lagoon littoral circulation pattern, to non-critical erosion along the southeasterly bluffs and seacliffs.

At Duxbury Point, about 6 miles southeasterly of Double Point, and about 2 miles from Bolinas Point, the Duxbury reef extends in a southerly direction and tends to disperse any wave energy coming

into Bolinas Bay from the northerly through westerly directions. The bay is crescent-shaped and open to the south. Bolinas Beach fronts on the northwesterly shore of Bolinas Bay and is rimmed by 140-foot-high vertical cliffs. The Bolinas shoreline lies within the San Andreas fault zone. Massive landslides have developed on the northern end of Bolinas Beach; and faulting, shearing, and undercutting by wave action has contributed to the instability of large parcels of private property above the seacliffs. Beach sand is fine to medium grained. Rocky tidal flats extend seaward from the beach for an additional 300 feet during periods of low tide. Stinson Beach, to the east of the channel entrance to the Bolinas Lagoon, is formed by a sandspit about 2 miles in length. Sandspit property has been developed into a residential subdivision of expensive homes. State Highway No. 1 provides access to the shoreline from Point Reyes Station to the Bolinas Lagoon and Stinson Beach. Erosion is a critical problem in the shoreline reach between Bolinas Point and Stinson Beach, a distance of about 5 miles. It is estimated that the annual rate of erosion is about 1 foot. In some sections between Bolinas Channel and Duxbury Point, the eroding bluffs have resulted in damage to existing public roadways. The bluff areas are very unstable when saturated, and undercutting wave action along the toe of the bluff results in the failure of large masses of material along slippage planes. Erosion along the Stinson Beach spit is not critical. Major erosion problems that threaten beaches or improvements are centered in the reach between Agate Beach and Bolinas Channel. A Corps of Engineers study has been completed and additional studies have been authorized to determine the economic feasibility of constructing necessary corrective improvements.

Bolinas Lagoon is separated from Bolinas Bay by the Stinson Beach sandspit. The lagoon is triangular in shape, about 2 miles long and 1.5 miles wide, and includes about 1,400 acres, of which 300 acres are privately owned and 1,100 acres are publicly owned. The lagoon is undeveloped. Because of the lack of depth, the lagoon is not used extensively for recreational navigation. About 1.5 miles of the 8 miles of shoreline bordering the lagoon are publicly owned.

Stinson Beach State Park occupies about 2 miles of shoreline just southeast of and adjacent to Stinson Beach. State Highway No. 1 forms the northeasterly boundary of the park area, and limits park width to an average of about 0.5 mile. Steep bluffs and rugged terrain lie just inshore of the park area, and a limited amount of residential development exists in this reach. Erosion is not critical. Fishing, swimming, and picnicking are the principal shoreline activities.

Toward Muir Beach, about 5 miles to the southeast, the shoreline becomes increasingly rugged with numerous offshore rocks. State Highway No. 1 continues parallel to the shoreline to the vicinity of Muir Beach, where it turns northeasterly away from the shoreline area.

The sandy beach at Muir Beach is 1,600 feet long and 500 feet wide, and is flanked by steep vertical seacliffs up to 170 feet in height. The beach faces toward the south and is sheltered by a very prominent headland to the west. Beach cover varies from very fine sand to cobbles up to 3 inches in diameter. The area is used for picnicking, scenic viewing, fishing and hiking. Homes have been constructed on the high cliffs overlooking the beach area. Erosion is not critical.

The 9-mile reach from Muir Beach through Point Bonita to the westerly side of the entrance to the Golden Gate continues steep and rugged, interrupted by several small sheltered pocket beaches, including Pirates Cove, Rodeo Cove, Tennessee Cove and Bonita Cove. The southerly 7 miles of the shoreline in this reach are parts of Fort Cronkite, Fort Barry, and Fort Baker military reservations. About half of this Federal shoreline is now within the Marin Headlands State Park. The area is undeveloped except for military facilities and a lighthouse at Point Bonita. Erosion is not critical.

San Francisco County

San Francisco County has a coastal shoreline length of about 8 miles or less than 6 percent of the subregion's total ocean shoreline. From the south abutment of the Golden Gate Bridge to the San Francisco-San Mateo County boundary, the shoreline is devoted almost entirely to recreational and related uses. The initial 1.6 miles of shoreline is within Fort Winfield Scott --commonly known as the Presidio -- and is under the jurisdiction of the 6th Army; about half of this shoreline has been opened to public use and comprises Bakers State Beach. The area is used for scenic viewing, picnicking and hiking. Other land uses are for military facilities and military housing. The shoreline is comprised of steep seacliffs overlooking relatively narrow, sandy and rocky beaches. The inshore area is hilly and varies from rolling hills to more rugged topography. There is no erosion problem in this reach.

The 2-mile reach downcoast from the Presidio includes James D. Phelan State Beach, Lincoln Park, Lands End, Seal Rocks State Beach, Point Lobos and Seal Rocks. This reach is characterized by steep seacliffs and narrow sandy and rocky beach areas. Numerous scenic views overlook the beaches. The area is used primarily for fine residences, public facilities, and specialized commercial developments. Many recreational and tourist-oriented facilities are located in this reach. Seals frequent Seal Rocks and may be viewed from the shoreline high ground. A scenic view drive, known as the 49-Mile Scenic Drive, traverses the entire San Francisco ocean shoreline and lies within several hundred feet of the shoreline. Erosion is not critical in this reach.

The reach from Seal Rocks, at the nationally-famous Cliff House restaurant, to the vicinity of Fleishhacker Zoo is about 3 miles. The terrain changes rapidly from high cliffs to sandy beaches. Beach width ranges upward to 100 feet, and the most northerly part of the beach, near the Cliff House, is protected by a concrete seawall 1 mile long. Back-shore developments include an amusement park and playland area adjacent to the Cliff House; 0.5 mile within Golden Gate Park; 2.0 miles of residential development; including a limited amount of light commercial development; and 0.5 mile within Fleishhacker Zoo. To the south, the beach area is backed by rolling hills and eroding seacliffs of Fort Funston, which extend to the San Francisco-San Mateo County Line. The upland area is developed in residential and related uses.

The beach area south of the Cliff House is subject to critical erosion, and the inshore residential areas are subject to invasion by windblown beach sands. The seacliff areas fronting Fort Funston and properties just south of Fleishhacker Zoo are subject to erosion. Studies either completed by the Corps of Engineers or currently underway indicate that erosion in this critical reach is related to an observable littoral transport to the north during about 9 months of the year and a reversal of direction to the south during the summer months. Many functionally related elements are involved: (1) the interactions between ebb and flow of ocean and flood waters through the Golden Gate; (2) transport of sediments from the San Francisco Bay and tributary streams through the Golden Gate, amounting to more than 5 million cubic yards a year; (3) the irreversible effects on stream sediment transport due to impoundments upstream; (4) annual maintenance dredging of about 10 million cubic yards of material within the San Francisco Bay system, and 1 million cubic yards just seaward of the Golden Gate in the San Francisco Bar Channel; (5) disposal of dredge spoils just seaward of the Golden Gate in increasing quantities in order to meet water quality standards within the bay, which are becoming more rigid with the passage of time; (6) the sheltering of the offshore Farallon Islands; and (7) the effect of Potato Patch Shoal, a large deposit of littoral material just seaward of the Golden Gate. Juxtaposition of these man-made and natural phenomena contributes to the complexities of littoral transport problems in this segment of the subregion's shoreline.

San Mateo County

San Mateo County has a coastal shoreline length of about 56 miles or about 37 percent of the subregion's ocean shoreline. From the San Francisco-San Mateo County boundary line to Mussel Rock, a reach of about 3 miles, the shoreline is characterized by steep seacliffs overlooking small flat beach areas. State Highway No. 1 is located atop the cliffs and separates most of the residential developments of this reach from the cliff face. Some residences are located seaward of the highway and are threatened by a serious erosion problem. The beach and

sand dune area in the north narrows as the cliff formations approach the shoreline in the south. The cliffs are interrupted by marine terrace formations at Thornton State Beach Park, a beach area about 0.6 mile long that includes about 50 acres of beach and overlook scenic view areas. The park is suitable for picnicking, scenic viewing and fishing. Thornton Beach is the most northerly of a group of beaches designated as the San Mateo Coast State Beaches. Lake Merced Golf and Country Club is located just east of the beach and the park area. Farther to the south toward Mussel Rock, the shoreline is composed of near-vertical sedimentary rocks which have been critically eroded and undermined by the sea. Some 30 active slide areas have been identified in this area. The erosion problem ranges from non-critical to critical in this reach. Principal land usage is residential.

The segment from Mussel Rock to Shelter Cove, near San Pedro Point, is 6.0 miles long. In this segment, the marine sedimentary rocks move landward and the shoreline formations are composed of marine terrace deposits through the Sharp Park district. In the Mori Point and Rockaway Beach areas, the shoreline is composed of intermittent seacliff and valley areas. Between Shelter Cove and San Pedro Point, marine sedimentary rocks form very rugged and steep seacliffs up to 400 feet in height. The reach from Mussel Rock to Mori Point is fronted by narrow beach, and the overlooking rock formations range from 40 to 150 feet in height. Toward the south, the beach widens gradually and includes stable sand dunes extending several hundred feet inland. Sharp Park Beach is located in this reach and is about 1.0 mile long and about 75 feet wide. Submerged rocks lie offshore at the north and south ends of the beach. Beach sands range from fine to very coarse grained, with isolated patches of pebbles up to 2 inches in diameter. The beach is terminated on the east by cliff formations that range from heights of 40 feet in the north to about 10 in the south. Erosion of the low seacliffs between Mussel Rock and Mori Point has resulted in extensive damage to private and public property. It has been estimated that erosion rates of from 1 to 2 feet a year will continue in this reach for the next 50 to 100 years. This critical erosion occurs by progressive undercutting of the bluffs by wave action, which in turn results in slides. The problem is particularly critical in the general vicinity of Sharp Park, for which a protection project is being studied.

Rockaway Besch, about 0.9 mile south of Mori Point, is a pocket beach about 1,500 feet long fronting a commercial resort development. The beach accumulates sand during the summer months and degrades during the winter, exposing a blanket of cobbles and boulders. Linda Mar Beach, a crescent-shaped beach about 4,000 feet long, is located in the San Pedro Valley reach between Rockaway Beach and Shelter Cove. The beach area is undeveloped because of lack of protection from wave action. Wave damage and inundation occur during severe storms. San Pedro Valley, located within 0.5 mile of the beach is a rapidly expanding

residential area. Shelter Cove Beach is a privately-owned, narrow beach about 800 feet long that is located at the base of cliffs about 200 feet high. The Shelter Cove resort area includes about 17 beach cottages. The general area is primarily residential, with local business developments to service the residents. Sharp Park Golf Course, operated by the City and County of San Francisco, is located just inshore of the Sharp Park State Beach. State Highway No. 1 runs close to the shoreline in this reach.

Between San Pedro Point and Pillar Point, a distance of about 8.0 miles, the topography is extremely rugged through the Devil's Slide and scenic overlook area to the northerly boundary of Montara Beach. The beach area is nearly 1 mile long and averages about 150 feet in width. Seacliffs in this area are 60 to 70 feet in height. The town of Montara overlooks the beach area from the south; and a lighthouse is located at Point Montara. Between Point Montara and Pillar Point, the upland area flattens and State Highway No. 1 provides access to the shoreline. Erosion is non-critical, except for critical erosion of the highway in places.

The Half Moon Bay segment extends about 8.0 miles from the Half Moon Bay small-craft harbor at Pillar Point to Miramontes Point. The area is rimmed by a 1/2-mile-wide, wave-cut terrace that is bounded by 50-foot seacliffs along the shore.

From Princeton Beach to Miramontes, a distance of 5.5 miles, the shoreline is comprised of unusually clean, wide and attractive sandy beach. Along the northerly part of the reach, low sand dunes are partially stabilized with beach grasses and other ground covers; in the southerly 2-mile reach, a low coastal bluff parallels the shoreline beach area. Inland terrain is gently rolling. Principal land uses are agriculture and residential, with some commercial development for tourism and local needs.

With the exception of the El Granada-Miramar area, beach erosion is not critical. At El Granada Beach, along a 4,600-foot front extending through Miramar Beach to the vicinity of Miramar, critical erosion has caused extensive damage to private and public property. It is estimated that erosion rates during the next 50 to 100 years in this reach will average about 4 feet a year. Without corrective measures, about 25 acres of land will be lost during the study period. An offshore reef extends southeasterly from Pillar Point and protects the beach areas from westerly and northwesterly storms. The effect of the reef and the headland area on erosion patterns and littoral transport is now under study by the Corps of Engineers with a view to providing corrective structures to control the problem.

Between Miramontes Point and the Pigeon Point Lighthouse, a distance of about 20 miles, the shoreline is comprised of a continuous stretch of beach backed by a narrowing inshore area that slopes moderately seaward and is used for agriculture. Within this segment, there are wide, sandy beaches, relatively rugged shoreline with many reefs, offshore rocks, sea caves and isolated coves. Low tides expose a multitude of excellent tidepools containing varied marine life. Surf display is outstanding, especially during winter storms. Coastal bluffs adjacent to the beaches vary in height from 25 to 125 feet. Principal beaches operated by the State of California, from north to south, include San Gregorio Beach, Pomponio Beach, Pescadero Beach, Pebble Beach, and Arroyo De Los Frijoles Beach. San Gregorio Beach, at the mouth of San Gregorio Creek, is a pocket beach, which is about 500 feet wide during summer months. Near-vertical seacliffs rise to heights of up to 100 feet behind the north and south flanks of the beach. Beach sands are fine to medium grained. The seacliffs are extensively undercut by erosion. The upland area is sparsely settled with small farms and country residences. Pescadero Beach is located at the mouth of Pescadero Creek. The junction of Pescadero and Butano Creeks, about 1,000 feet inland from the coast, forms a marsh with several isolated pools and sloughs. The mouth of Pescadero Creek is marked by a steep bluff that forms an abrupt headland protruding northwest. To the south, the shoreline is very irregular and there are many offshore rocks. Pescadero Beach is about 3,000 feet long and varies from 200 to 400 feet in width. Beach sands vary from fine to medium grained. The north flank of the beach is rimmed by 80-to 90-foot vertical cliffs. The major part of the shoreline area is devoted to agricultural use. Residential development is limited. Erosion of seacliffs occurs, but is not considered critical.

From Pigeon Point to Point Ano Nuevo, a distance of about 8.0 miles, the shoreline area has limited agricultural use and is largely undeveloped. Between Pigeon Point and Franklin Point, a clean, wide beach about 1.0 mile long is used for recreation. The leeward side of Franklin Point is a low coastal bluff with many offshore rocks, reefs, and sea caves. Sand dunes from 10 to 15 feet high are prevalent around Franklin Point. Inland, the dunes terminate in chaparral. Many of the dunes are partially stabilized with beach grass and other ground covers. Stock grazing and agricultural uses predominate. South of Franklin Point to Point Ano Nuevo, the shoreline is comprised of rocky and pebbly beaches interspersed with occasional small, sandy beaches. From Point Ano Nuevo to just north of the mouth of Ano Nuevo Creek, 70 to 100-foot high, near-vertical cliffs rise out of the ocean. A sandy beach immediately north and south of the mouth of Ano Nuevo Creek is about 2,000 feet long and 75 to 150 feet wide, and is backed by windblown sand dunes that have accumulated at the base of the seacliffs. Beaches to the southeast of the creek mouth are private property. The remainder of the beach is a state park. The upland area north

of Point Ano Nuevo is agricultural. The area surrounding the point is a state reserve. Erosion is not considered critical. State Highway No. 1 parallels this reach within 1-1/2 miles of the shoreline.

DESCRIPTION OF SAN FRANCISCO BAY SHORELINE

General

The shoreline of San Francisco Bay is about 276 miles long, exclusive of the shorelines of tributary streams, sloughs and islands; and includes the shorelines of Marin, Sonoma, Napa, Solano, Contra Costa, Alameda, Santa Clara, San Mateo and San Francisco Counties. Shoreline development includes about 5 percent agricultural; 40 percent urban; 10 percent military; 5 percent harbor facilities; and about 40 percent marshes and undeveloped lands. The critical erosion areas are few because of the substantial extent of levees and revetments to protect reclaimed areas. Substantial erosion has been observed at Fort Point, near the south abutment of the Golden Gate Bridge; and critical erosion is occurring at the Alameda Memorial State Beach Park, of the City of Alameda. Adequate access to all parts of the bay shoreline is available from state and local roads. The following paragraphs describe the bay shoreline, by county, beginning with Marin County and proceeding clockwise.

Marin County

Marin County has a bay shoreline length of about 45 miles or about 16 percent of the total bay shoreline of 276 miles. From Lime Point, at the north abutment of the Golden Gate Bridge, to Sausalito Point, the shoreline is extremely rugged and has numerous scenic view sites that overlook the bay. In 1965, much of this reach was within Fort Baker Military Reservation; a major portion is now a part of the Marin Headlands State Park. Toward Sausalito Point, numerous residences occupy choice view sites overlooking Richardson Bay. The shoreline between Sausalito Point and Al Monte forms the southwest shore of Richardson Bay. The Northwestern Pacific Railroad and U.S. Highway No. 101 cross this reach. Development is essentially urban, comprised of shipbuilding and other industrial activities. A peninsula, Strawberry Point, emerges from the west shore of Richardson Bay. This peninsula includes rolling hills and intermittent marsh areas. The backshore area is primarily urban. Local roads provide access to the peninsula. The Tiburon Peninsula forms the northeast shore of Richardson Bay and a segment of the southwest shore of the Central San Francisco Bay, and overlooks Angel Island State Park across Raccoon Strait to the southeast. The park is located on Angel Island, which has a shoreline about 5.5 miles long. Access to the island is by boat only. The Tiburon Peninsula is extremely hilly and scenic, and is considered to be a choice residential area. Belvedere Island is linked to the peninsula's southerly boundary. A branch of the Northwestern

Pacific Railroad runs close alongshore to Point Tiburon. State Highway No. 1 provides access to this reach from U.S. Highway No. 101. Residential areas are concentrated at Belvedre and Tiburon, and scattered residences are located throughout the peninsula. The San Francisco Yacht Club and the Corinthian Yacht Club are located at Belvedere Cove. The Tiburon Naval Net Depot and two small county parks are located in the vicinity of Point Chauncey. From Point Chauncey to the mouth of San Clemente Creek, the overlooking hills range from 300 to 700 feet in height. Scattered residences are located in the hills, and a large residential development is located in the flats at Paradise Cay. Marsh area extends to the base of Punta De Quentin (Point San Quentin). San Quentin State Prison is located on this point, near the west abutment of the Richmond-San Rafael Bridge. Between Point San Quentin and Point San Pedro, a crescent-shaped shoreline bisected by San Rafael Creek forms San Rafael Bay, which faces southeast. The City of San Rafael lies north of San Rafael Creek. This reach is primarily urban in development. From Point San Pedro to the Petaluma River, at the Marin-Sonoma county boundary, the hills merge rapidly into a long leveed marsh area that extends northerly to Hamilton Air Force Base and the county boundary. Except for McNear Beach, near Point San Pedro, and military use at Hamilton Air Force Base, the shoreline is largely undeveloped. Backshore usage is agricultural and urban.

Sonoma County

Sonoma County has a bay shoreline length of about 8.0 miles or about 3 percent of the total bay shoreline. The entire shoreline reach from the Petaluma River to Sonoma Creek is leveed marshland and mudflats. The Northwestern Pacific Railroad runs parallel to the shore to Tolay Creek, and then turns northward. State Highway No. 37 (the Black Point Cutoff) runs parallel to the railroad at a distance of about 0.5 mile inland and an average of 1.5 miles from the shoreline interface.

Napa County

The Napa County bay shoreline is virtually zero. The Marin, Napa, and Solano County Boundary lines meet at a point on Sonoma Creek just off the bay shoreline interface.

Solano County

Solano County has a bay shoreline length of about 52 miles or about 19 percent of the total bay shoreline. From the mouth of Sonoma Creek to the U.S. Naval Reservation at Mare Island, the shoreline is marshland, some of which has been reclaimed for agricultural purposes. The Naval Reservation is bounded by the Mare Island Strait at the

mouth of Napa River. The Mare Island Naval Reservation includes shipyard and repair facilities and accommodations for naval personnel. The entire reach is of very low elevation, and much of the marshland serves as fish and wildlife reserves. From the Mare Island Strait through the Carquinez Strait to Benicia Point, the terrain is generally steep and rugged. The shoreline is interrupted by Dillon Point, which juts into the strait, and Southhampton Bay, which recedes from the strait and is a shallow and muddy cove lying at the mouth of a long, narrow marsh. Toward Benicia, the shoreline becomes less rugged and numerous small residences dot the backshore area. A former military reservation, Benicia Arsenal, has been replaced by an industrial project developed by Benicia Industries. Humble Oil Company has built a new refinery just north of Benicia and a harbor facility has been developed. Beyond Benicia, the shoreline is swamp and slough, extending to the northeast and east to form a large, shallow bay. The shoreline then turns southerly to Point Buckler, at the Suisun Cutoff separating Simmons Island on Grizzly and Suisun Bays from Ryer Island and Roe Island, which lie in Suisun Bay. From Point Buckler to Chipps Island, the shoreline bounds Honker Bay and Suisun Bay to the upstream limit of the San Francisco Bay subregion. The entire shoreline is leveed and unleveed marshland. These marshlands are highly valued as wildlife preserves.

Contra Costa County

Contra Costa County has a bay shoreline of 54 miles or about 20 percent of the total bay shoreline. From the vicinity of Mallard Island, near West Pittsburgh, to the vicinity of Port Chicago, the shoreline consists of marshland, some of which has been reclaimed for industrial and utility use and for a small-boat harbor at McAvoy. The main lines of the Atchison, Topeka and Santa Fe and the Southern Pacific railroads parallel the shoreline about 1 mile inland. State Highway No. 4 provides access to shoreline facilities and developments. From the shoreline interface to the railroads, the land is very flat. Landward of the railroads, the land rises at a moderately steep rate. Land uses vary from undeveloped to industrial. A strong trend toward industrial development exists; however, substantial areas are still used for agriculture. Between Port Chicago and the bridges at Martinez, the shoreline is principally marshland. Major petroleum refinery and storage facilities are located at Amorco and Martinez. Population centers are located at Avon, inland from Amorco, and Martinez. Land use varies from agricultural to residential and industrial. The shoreline is very flat, but becomes quite hilly in the vicinity of Martinez. Between Martinez and the petroleum refinery at Oleum, through Carquinez Straits, the shoreline is steep and rugged. A sugar refinery is located just upstream of the south abutment of the Carquinez bridges at Crockett. The Southern Pacific Railroad runs at the base of the hills and cliffs and adjacent to the shoreline. Scattered urban areas and industrial developments characterize this area. Much of the area is undeveloped

or in agriculture. Between Oleum Pier and Pinole Point, the shoreline varies from rolling hills to marshlands. Numerous small industrial communities and industrial areas are separated by agricultural lands and undeveloped areas. The Southern Pacific and Atchison, Topeka and Santa Fe Railroads are located near the shoreline, and highways and connecting local roads traverse the area. Between Pinole Point and Point San Pablo, the shoreline is quite variable and includes a hilly area at Pinole Point, flat lands and marsh areas toward the mouth of Wildcat Creek, and rugged terrain leading toward the San Pablo Strait at Point San Pablo. Much of the shoreline is within the boundaries of the City of Richmond. The Standard Oil Company refinery is located at the base of Point San Pablo in the City of Richmond, just off the approach area to the Richmond-San Rafael Bridge. Uses of the shoreline vary from residential to industrial and some areas are undeveloped. Between Point San Pablo and Point Isabel, heavy industries are situated in the vicinity of the Standard Oil Company Refinery and the Santa Fe Railroad terminal facility at Richmond. A Naval Fuel Supply Depot and Reservation and the Point Molate Beach Park occupy the shoreline in the vicinity of Point Molate between Point San Pablo and Castro Point. The county beach is about 2,000 feet long. Another county beach, about 400 feet long, is located at Keller's Beach Park between Castro Point and Point Richmond. The Richmond Harbor and shipbuilding facilities are located between Point Richmond and Point Isabel. A training wall, which extends westerly from Brooks Island, flanks the harbor entrance channel across from Point Potrero. A University of California Engineering Field Station is located off the Richmond Inner Harbor toward Point Isabel. The general area is heavily populated and overall development is urban.

Alameda County

Alameda County has a bay shoreline of about 58 miles or about 21 percent of the total San Francisco Bay shoreline. From Albany Hill to the east abutment and approach ramp to the San Francisco-Oakland Bay Bridge, the shoreline lies within the city limits of Albany, Berkeley, and Emeryville. The shoreline developments include Golden Gate Fields at Fleming Point, which is bisected by the Albany-Berkeley boundary line. To the south, just north of the Berkeley Aquatic Park, a Municipal Heliport is located just inshore of the Berkeley Yacht Harbor and Marina. Farther to the south, the shoreline is undeveloped. The backshore development is industrial and residential, and the development at Emeryville is largely industrial. The Southern Pacific Railroad runs parallel to the shoreline just inshore from the East Shore Freeway, which is denoted as Interstate Highway No. 80. From the southerly boundary of Emeryville to the Metropolitan Oakland International Airport, the shoreline passes through the Oakland Army Terminal; the Naval Supply Depot; the Outer and Inner Harbors of Oakland Harbor; the Alameda Naval Air Station; the 8,100-foot-long Alameda Memorial State Beach

(which has a critical erosion problem); the 6,600-foot-long Alameda City Beach fronts a shoreline residential development, San Leandro Bay and the shoreline of Bay Farm Island, which is adjacent to the airport. The shoreline area is within the city limits of Oakland and Alameda. Development is military, industrial, and urban. From the airport to the San Mateo-Hayward Bridge, the shoreline is basically marsh and tidelands. The northerly portion of the shoreline within San Leandro City limits, adjacent to the Oakland-San Leandro boundary line, has been reclaimed and includes a residential development, a golf course, and a small-boat lagoon and marina. The remaining shoreline is tidal flatlands. Backshore development is urban. From the San Mateo-San Leandro Bridge to the mouth of Coyote Creek, at the Alameda-Santa Clara county boundary line, the shoreline is marshlands and is diked off for evaporation of ocean waters for commercial production of salt and chemical byproducts. Backshore developments are urban and agricultural.

Santa Clara County

Santa Clara County has a bay shoreline of about 10 miles, less than 4 percent of the total bay shoreline. The entire shoreline is marshland and sloughs, most of which is diked off for production of salt by evaporation of ocean waters. Near the City of Palo Alto, the shoreline has been developed to create the Palo Alto Municipal Airport, a municipal golf course, and a yacht club and marina. Backshore development is urban and agricultural.

San Mateo County

San Mateo County has a bay shoreline of about 33 miles or about 12 percent of the total bay shoreline. From the San Mateo-Santa Clara county boundary line to Belmont Slough and Foster City, the shoreline is tidelands and marshlands. Most of the shoreline area has been diked off for salt evaporating ponds for commercial production of salt. Redwood City Harbor, located near the mouth of Redwood Creek, provides terminal facilities for deep-draft commercial vessels. Small-boat marina facilities are available in this area to accommodate recreational boating. Commercial terminal facilities are connected by spur tracks to the Southern Pacific Railroad mainline track, which parallels the shoreline. The Bayshore Freeway (U.S. Highway No. 101, Alternate) parallels the shoreline just shoreward of the railroad. Backshore development is urban with large residential areas in the shoreline cities of Menlo Park, Atherton, Redwood City, San Carlos and Belmont. Industrial developments are located in the flats and tidelands near the shoreline, and the residential areas are located landward from the lowland industrial and commercial developments. Backshore residential areas in the more northerly portions of this reach occupy large view sites in highland areas overlooking the bay. From Brewer Island (Foster City) to the San Francisco International Airport, the tidelands have been reclaimed for residential and light industrial usage, and in the

immediate vicinity of the airport, related commercial and industrial developments which directly support aviation activities occupy large tracts of reclaimed tidelands and marshlands. The Bayshore Freeway and the Southern Pacific Railroad run parallel to the shoreline, and the freeway provides access to the airport and adjacent communities. Land use is urban. Large residential areas are located in the shoreline communities of San Mateo, Hillsborough, Burlingame and Millbrae. A municipal golf course, a recreational-boating marina, and a small county beach about 1,200 feet long, are located at Coyote Point. Between the airport and San Francisco-San Mateo County boundary line, the reclaimed tideland and marsh areas are occupied by a large variety of commercial, industrial, and heavy industrial developments as far as Oyster Point. Beyond Oyster Point, the shoreline of the Bayshore Freeway forms the easterly boundary of a huge refuse dumping area which is bounded on the west by the Southern Pacific Railroad right-of-way. It is anticipated that the land reclaimed by the disposal and fill process will be developed for industrial purposes. East of the dumping area and adjacent to the county boundary line, the Southern Pacific Maintenance and Repair Shops occupy about 200 acres of the reclaimed tideland areas. A chemical plant and other industrial developments are located westward and shoreward of the railroad shops in this reach. The flatlands shoreward of the railroad area are near zero elevation. Landward elevations rise steeply at Brisbane, and less abruptly in the more southerly portions of this reach near South San Francisco and San Bruno. Land use is urban except for San Bruno Mountain, which is undeveloped except for a few scattered residences.

San Francisco County

San Francisco County has a bay shoreline length of about 15 miles or about 6 percent of the total bay shoreline. From the San Francisco-San Mateo County boundary to the Hunters Point Naval Reservation, the shoreline is occupied by Candlestick Park, a ball park, and many urban and industrial developments including substantial manufacturing activities. From the naval shipyard at Hunters Point to the vicinity of Fisherman's Wharf, the shoreline is developed for industry and the terminal facilities of San Francisco Harbor. Immediately backshore of the shoreline developments, large residential and commercial areas occupy the flat and rolling hill areas. Farther backshore, the land is increasingly precipitous and rugged. Toward the North Beach area, Nob Hill and other highlands overlook the Rincon Point to North Point areas of the shoreline. This scenic heights area is north of the main business and financial center of San Francisco. From North Point and Fisherman's Wharf to Fort Point, at the south abutment of the Golden Gate Bridge, the shoreline includes an aquatic park that has a beach about 2,000 feet long, the San Francisco State Historical Park, a maritime museum, the Fort Mason Military Reservation, a marina and yacht harbor, and the Presidio Millitary Reservation (Fort Winfield Scott). Land use is urban and military in character. The Presidio occupies about 2 square miles of shoreline and backshore area, and

fronts on both the bay and ocean shorelines. Magnificent view sites are found in the Presidio knoll and hill areas. A panoramic view of the Golden Gate Bridge is available from U.S. Highway No. 101 as it approaches the Golden Gate Bridge through the Presidio. A critical erosion problem exists in the vicinity of Fort Point at the south abutment of the Golden Gate Bridge. Continuing efforts to stabilize the cliff area in the eroding section have been unsuccessful, and the existing rock revetments and walls have been subjected to extensive damage. Offshore islands, within the city and county boundary line, include Alcatraz Island, a small rock formation offshore from the San Francisco shoreline. The island has been abandoned as the site of a Federal penetentiary and has recently been proposed as a national park. Also included are Yerba Buena and Treasure Island, which lie between San Francisco and Oakland. The center abutments of the San Francisco-Oakland Bay Bridge are on Yerba Buena Island. Treasure Island is a reclamation project constructed adjacent to Yerba Buena Island, and now houses a Naval Reservation. The island was reclaimed with fill using dredged materials from the bay.

LAND USE

Land use in the subregion's coastal shoreline zone is predominantly public reserve. About 52 percent of coastal shoreline zone is in this category; two-thirds of this public reserve is in Marin County. Urban land use accounts for 10 percent of the coastal shoreline zone. San Francisco County is the most urban, with practically half of its shoreline in urban use. Agricultural uses occupy 16 percent of the coastal shoreline zone; military uses occupy 4 percent; and harbors and other uses, combined, occupy the remaining 18 percent.

The shoreline zone comprising the perimeter of San Francisco Bay has about 52 miles of urban land use, or 19 percent of the bay shoreline. Major cities are San Francisco, Oakland, Berkeley, Richmond, San Mateo, Alameda, Vallejo, Palo Alto, Redwood City, Fremont and South San Francisco. Other land uses are agriculture, military, and harbors, each of which occupies about 9 percent of the bay's shoreline zone. Public reserve comprises less than 2 percent. The remaining 52 percent of the shoreline zone of San Francisco Bay is in "other" land uses. Included in this category is about 27 miles of salt ponds. Land uses in the subregion's shoreline zone are summarized in the following tabulation, and are shown on Map 3.

County	Land use, in shoreline miles						
	Urban	Agri-culture	Military	Public reserve	Harbors	Other	Total
COASTAL SHORELINE							
Sonoma	0.8	3.5	0	11.3	0.1	1.6	17.3
Marin	2.7	0.6	3.7	52.6	0.5	10.1	70.2
San Francisco	3.8	0	2.6	1.8	0	0.2	8.4
San Mateo	8.6	20.3	0	12.4	0	14.6	55.9
Total, coastal	15.9	24.4	6.3	78.1	0.6	26.5	151.8
BAY SHORELINE							
Marin	9.1	4.7	3.4	0.7	5.1	22.0	45.0
Sonoma	0	6.4	0	0	0	1.6	8.0
Napa	0	0	0	0	0	0	0
Solano	1.7	8.2	6.6	0	0	35.9	52.4
Contra Costa	8.3	5.6	4.6	0	6.8	28.7	54.0
Alameda	19.0	0.8	4.5	2.8	6.2	24.7	58.0
Santa Clara	0	0	0	0	0.6	9.4	10.0
San Mateo	11.9	0	0	0.7	0.6	20.1	33.3
San Francisco	2.0	0	6.3	0.7	5.8	0.5	15.3
Total, bay	52.0	25.7	25.4	4.9	25.1	142.9	276.0

OWNERSHIP

In 1965, public ownership of shoreline land in the subregion totalled about 65 miles, or 43 percent, of the coastal shoreline; and about 75 miles, or 27 percent, of the bay shoreline. Most of the publicly-owned shoreline consists of Federal military reservations, Federal parks, State parks and beaches, county parks and beaches, harbors, airports, utility districts, and recreation sites. Privately-owned shoreline includes agricultural, residential, commercial, industrial and recreational developments, and extensive undeveloped shoreline. Shoreline ownership is summarized in the following tabulation, and is shown on Map 3.

County	Land ownership, in shoreline miles					
	Public				Private	Total
	Federal	State	Local	Subtotal		
			COASTAL SHORELINE			
Sonoma	0	11.0	1.6	12.6	4.7	17.3
Marin	22.3	4.1	0.1	26.5	43.7	70.2
San Francisco	1.4	0.7	5.6	7.7	0.7	8.4
San Mateo	0.9	15.1	2.0	18.0	37.9	55.9
Total, coastal	24.6	30.9	9.3	64.8	87.0	151.8
			BAY SHORELINE			
Marin	3.4	1.5	2.5	7.4	37.6	45.0
Sonoma	0	0	0	0	8.0	8.0
Napa	0	0	0	0	0	0
Solano	6.6	6.4	0	13.0	39.4	52.4
Contra Costa	4.6	0.6	4.4	9.6	44.4	54.0
Alameda	4.5	5.5	13.3	23.3	34.7	58.0
Santa Clara	0	0	0.6	0.6	9.4	10.0
San Mateo	0	0	5.6	5.6	27.7	33.3
San Francisco	7.4	2.1	5.5	15.0	0.3	15.3
Total, bay	26.5	16.1	31.9	74.5	201.5	276.0

RECREATIONAL SHORELINE

Of the 65 miles of publicly-owned coastal shoreline in 1965, about 49 miles are non-swimming beach. These beaches are generally used for fishing, picnicking, clam digging, SCUBA diving, hiking and camping. Because of the climate, exposure, and ocean water temperatures, none of the coastal beaches are classified as swimming beach. Of the total of about 75 miles of publicly-owned shoreline along the bay perimeter, about 4 miles are classified as swimming beach. Water temperatures and exposure within the bay are conducive to beach use for swimming during the summer season; however, the pollution problem that affects most of the bay tends to limit the use of otherwise satisfactory beaches for this purpose.

About 31 miles of scenic shoreline along the subregion coast are within public parks and military reservations and available for public use, although there is limited access to some areas and some restrictions on use of military properties. About 80 percent of the coastal scenic shoreline is in the county of Marin. None of the bay shoreline meets the National Park Service criteria for natural scenic shoreline.

Public recreational and scenic shoreline available in 1965 is summarized in the following tabulation, and is shown on Map 4.

County	Recreational and scenic shoreline, in miles		
	Swimming beach	Non-swimming beach	Scenic shoreline
	COASTAL SHORELINE		
Sonoma	0	12.8	2.3
Marin	0	25.3	25.1
San Francisco	0	3.4	0
San Mateo	0	7.5	3.6
Total	0	49.0	31.0
	BAY SHORELINE		
Marin	0.2	0	0
Sonoma	0	0	0
Napa	0	0	0
Solano	0	0	0
Contra Costa	0.4	0	0
Alameda	2.8	0	0
Santa Clara	0	0	0
San Mateo	0.2	0	0
San Francisco	0.4	0	0
Total	4.0	0	0

EROSION CHARACTERISTICS

Geologically speaking, essentially the entire shoreline is eroding to some degree. However, for the purpose of this report, erosion characteristics have been classified into three categories -- critical erosion, non-critical erosion, and non-eroding. These categories are defined in the Introduction. About 10 miles, or 6 percent of the subregion's coastal shoreline is considered subject to critical erosion, which threatens urban and military properties and public roads and highways. Non-critical erosion is affecting about 117 miles or 77 percent of the coastal shoreline. The remaining 26 miles of coastal shoreline, consisting of rocky cliffs, sand dunes and rocky headlands, are considered non-eroding or stable.

About 3.6 miles of bay shoreline, or 1.3 percent, is subject to critical erosion that is threatening a beach and adjacent shoreline in Alameda County and revetted shoreline in San Francisco County at the mouth of the Golden Gate. About 243 miles or 88 percent of the bay shoreline is eroding at a non-critical rate. The remaining 30 miles of bay shoreline is non-eroding or stable. It includes harbor shorelines and other reaches that are directly or incidentally protected by structures, such as breakwaters or terminal facilities that have been built for other purposes, but which modify potentially erosive bay currents. Erosion rates in the subregion range from zero, in non-eroding reaches, to about 4 feet a year. The higher rate is occurring in critically-eroding reaches along the San Mateo County coast. Erosion characteristics are summarized in the following tabulation and are shown on Map 5.

County	Erosion characteristics, in miles			
	Critical	Non-critical	Non-eroding	Total
		COASTAL SHORELINE		
Sonoma	0.3	12.4	4.6	17.3
Marin	0.9	58.4	10.9	70.2
San Francisco	2.2	1.8	4.4	8.4
San Mateo	6.2	43.9	5.8	55.9
Total	9.6	116.5	25.7	151.8
		BAY SHORELINE		
Marin	0	40.8	4.2	45.0
Sonoma	0	8.0	0	8.0
Napa	0	0	0	0
Solano	0	49.8	2.6	52.4
Contra Costa	0	51.5	2.5	54.0
Alameda	3.0	52.2	2.8	58.0
Santa Clara	0	10.0	0	10.0
San Mateo	0	24.5	8.8	33.3
San Francisco	0.6	6.1	8.6	15.3
Total	3.6	242.9	29.5	276.0

PROTECTIVE AND MITIGATIVE EFFORTS

General

The term "protection," as used in this report, refers to both structural and non-structural measures for the reduction of damages caused by shoreline erosion. Structural measures include such works as stabilization and beach fill, seawalls and revetments, and periodic replenishment of existing beaches. Non-structural measures refer to the zoning and regulating of shoreline uses. The term "development" refers to the creation of new beaches and acquisition of scenic shoreline for public recreational use. Accomplishments related to these activities are discussed in the following paragraphs.

Federal Projects

The authorities under which Federal beach erosion control and shore protection projects may be undertaken are described in the Regional Summary. No Federal projects have been authorized for construction for the San Francisco Bay subregion. On 27 July 1946, the State Division of Beaches and Parks made formal application for a continuing cooperative Federal-State study of the entire Pacific Coast shoreline of the State of California. Included in this study were 16 beach sites located between the mouth of Russian River on the north and Point Ano Nuevo on the south in the San Francisco Bay subregion. Other comprehensive cooperative studies have been initiated and are continuing. In addition, beach erosion studies, at Federal expense, have been initiated at Bolinas, San Francisco County, Pacifica and El Granada on the subregion coast and at Alameda Memorial State Beach within the bay.

Non-Federal and Private Work

Local interests have constructed a substantial concrete seawall about 1 mile long on the coastal shoreline to protect San Francisco Beach and the adjacent backshore playland area from erosion and have placed derrick stone along critical reaches of the bay shoreline to protect perimeter highways and freeways. Substantial reaches of the bay shoreline are protected by rock-revetted levees constructed in connection with reclamation of bay tidelands and the operation of numerous commercial salt ponds. No substantial beach erosion projects sponsored by local interests are now in progress within the subregion.

Non-structural Measures

The National Park Service has the responsibility for development and establishment of scenic shorelines by acquiring and maintaining shoreline sites for national parks, monuments, recreation areas and national seashores. An example is the Point Reyes National Seashore, referred to previously, which includes about 44 miles of scenic shoreline in Marin County and will add about 65,000 acres of scenic park and

beach areas to the public domain for public use when acquisition is completed. The State of California, through its Department of Parks and Recreation, also may exercise its authority to acquire and develop state parks and beaches and preserve scenic shoreline. Military reservations in Marin County also provide scenic shoreline. None of the bay shoreline is classed as scenic shoreline, as that term is defined in this report. Existing Federal authority with regard to beach development limits Federal participation to restoration of existing beaches that have been eroded and to such development of beaches as may be incidental to shore protection project purposes.

SHORELINE EROSION DAMAGE, PRESENT CONDITIONS

Estimates of shoreline erosion damages under present conditions were based on land use, rate of erosion, and market value of shoreline property that is subject to erosion damage. A detailed explanation of the method used for evaluating erosion damage is given in the Regional Summary.

The estimated average annual shoreline erosion damages, under present conditions, for the subregion's coastal and bay shorelines are shown in the following tabulation.

County	Average annual shoreline erosion damage, in $1,000	
	Coastal shoreline	Bay shoreline
Sonoma	$ 75	$ 7
Marin	150	53
San Francisco	250	45
San Mateo	525	40
Napa	-	0
Solano	-	16
Contra Costa	-	64
Alameda	-	172
Santa Clara	-	3
Total	$1,000	$400

Future Needs in the Shoreline Zone

GENERAL

Future needs are evaluated in terms of reducing shoreline erosion damages and meeting the needs for recreational shoreline, including conservation of scenic shoreline. A detailed explanation of the method used to evaluate erosion damages, and the means whereby these damages could be reduced is contained in the Regional Summary. The Regional Summary also contains a detailed explanation of the methods used to evaluate the needs for recreational shoreline.

SHORELINE EROSION DAMAGES, FUTURE CONDITIONS

The dollar value of future coastal erosion damages was estimated by applying economic growth factors based upon population projections and related economic indices to data for the base year (1965). It was assumed that, on the average, erosion rates would remain constant and that no erosion-control projects would be constructed during the study period. Inside the Bay, where over half of the shoreline land

has been reclaimed by filling and protection provided in accordance with use, and where the combination of relatively small waves and favorable topography have resulted in a generally slow rate of erosion, it has been assumed that future changes in land use would be accompanied by suitable protection, as in the past, and that zoning of the shoreline to restrict use in the erosive zone, as proposed for the coastal shoreline, would not be necessary. Further, it has been assumed that the San Francisco Bay Conservation and Development Commission (BCDC), which has jurisdictional control of the use of the Bay shoreline, would regulate shoreline use with respect to minimizing future erosion damages. The average annual shoreline erosion damages, under present and future conditions, for the subregion's coastal and bay shorelines are shown in the following tabulation.

County	Average annual shoreline erosion damages, in $1,000			
	1965	1980	2000	2020
COASTAL SHORELINE:				
Sonoma	75	90	130	160
Marin	150	250	520	640
San Francisco	250	460	1,010	1,250
San Mateo	525	900	1,840	2,250
Subtotal	1,000	1,700	3,500	4,300
BAY SHORELINE:	400	400	400	400
Subtotal	400	400	400	400
SUBREGION TOTAL	1,400	2,100	3,900	4,700

SHORELINE RECREATION NEEDS

Projected needs for recreational beaches are based upon projections of population for the San Francisco Bay subregion and adjacent inland subregions. Projected needs for conservation of scenic shoreline are based upon the availability of the resource and recommendations of the National Park Service, the State of California and other government entities. Due to unfavorable climate and exposure, none of the coastal beaches are classified as swimming beach and projected demands are estimated as zero, accordingly.

The projected coastal and bay public recreational shoreline requirements for the San Francisco Bay subregion are shown in the following tabulation.

County	Cumulative Public Recreational Shoreline Needs, in Miles			
	1965	1980	2000	2020
COASTAL SHORELINE:				
Sonoma County				
Swimming beach	0	0	0	0
Non-swimming beach	4.4	6.4	10.2	14.0
Scenic shoreline	2.3	2.3	2.3	2.3
Marin County				
Swimming beach	0	0	0	0
Non-swimming	4.6	6.6	11.3	18.0
Scenic shoreline	25.1	53.2	53.2	53.2
San Francisco County				
Swimming beach	0	0	0	0
Non-swimming beach	4.8	5.6	6.3	7.0
Scenic shoreline	0	0	0	0
San Mateo County				
Swimming beach	0	0	0	0
Non-swimming beach	5.2	6.4	11.2	18.0
Scenic shoreline	3.6	9.5	9.5	9.5
Total				
Swimming beach	0	0	0	0
Non-swimming beach	19.0	25.0	39.0	57.0
Scenic shoreline	31.0	65.0	65.0	65.0
BAY SHORELINE:				
Marin County				
Swimming beach	0.2	0.6	0.7	0.8
Non-swimming beach	0	0.2	0.2	0.3
Scenic shoreline	0	0	0	0
Sonoma County				
Swimming beach	0	0	0	0
Non-swimming beach	0	0	0	0
Scenic shoreline	0	0	0	0
Napa County				
Swimming beach	0	0	0	0
Non-swimming beach	0	0	0	0
Scenic shoreline	0	0	0	0

County	Cumulative Public Recreational Shoreline Needs, in Miles			
	1965	1980	2000	2020
Solano County				
Swimming beach	0	0.1	0.2	0.8
Non-swimming beach	0	0	0	0.1
Scenic shoreline	0	0	0	0
Contra Costa County				
Swimming beach	0.4	0.9	1.5	2.2
Non-swimming beach	0	0.1	0.1	0.2
Scenic shoreline	0	0	0	0
Alameda County				
Swimming Beach	2.7	3.0	3.5	5.4
Non-swimming	0	0.3	0.3	0.6
Scenic shoreline	0	0	0	0
Santa Clara County				
Swimming beach	0	0.2	0.4	0.6
Non-swimming beach	0	0	0	0.1
Scenic shoreline	0	0	0	0
San Mateo County				
Swimming beach	0.3	1.8	4.3	5.8
Non-swimming beach	0	0.3	0.3	0.6
Scenic shoreline	0	0	0	0
San Francisco County				
Swimming beach	0.4	0.4	0.4	0.4
Non-swimming beach	0	0.1	0.1	0.1
Scenic shoreline	0	0	0	0
Total				
Swimming beach	4.0	7.0	11.0	16.0
Non-swimming beach	0	1.0	1.0	2.0
Scenic shoreline	0	0	0	0
SUBREGION TOTAL:				
Swimming beach	4.0	7.0	11.0	16.0
Non-swimming beach	19.0	26.0	40.0	59.0
Scenic shoreline	31.0	65.0	65.0	65.0

Means to Satisfy Future Needs in the Shoreline Zone

GENERAL

The shoreline program for the subregion includes structural and non-structural protective measures to reduce potential future damages, the development of additional swimming beach, and the acquisition of shoreline for public recreational use.

STRUCTURAL MEASURES

In the development of the structural phase of the shoreline program, emphasis was placed on those urban and public recreational areas that are being threatened with critical erosion; and on the development of new sandy beaches within the bay. Of the total of nearly 10 miles of critical erosion along the subregion's shoreline, more than 6 miles occurs in San Mateo County and threatens backshore urban improvements and public roads located on shoreline bluffs and seacliffs. Most of the critical erosion along the bay shoreline occurs in Alameda County along a 3-mile beach frontage.

Structural measures, such as stabilization and beach replenishment, in addition to affording protection from erosion, would provide beach areas for public recreation as an incidental by-product. These beach areas, together with existing beaches and the 10 miles of newly-developed beaches within the bay would be available to meet projected public beach requirements during the study period. Non-structural protection of eroding areas by means of shoreline management is discussed in subsequent paragraphs.

Table SF-1, at the end of this chapter, shows the potential shoreline protection and development program for the subregion, by time frames.

NON-STRUCTURAL MEASURES

As shown in Table SF-1, the shoreline structural protection program for most of the subregion is minimal during the study period. A major part of the shoreline (65 miles) has been or will be acquired as scenic shoreline, and management or other non-structural measures should be implemented in order to minimize erosion damages. Non-structural measures should also be applied to the remainder of the shoreline to restrict urban encroachment into the shoreline erosive zone.

In 1965 the State of California created the Bay Conservation and Development Commission to establish and administer regulations pertaining to the management of San Francisco Bay and the bay's shoreline resources. Similar proposals have been presented to the State Legislature that would establish State and regional commissions to deal with

the problems associated with the conservation and development of the California coastal zone. The proposals include long-range comprehensive coastal zoning plans and criteria and standards for numerous environmental factors that could, if uncontrolled, detrimentally change or irreversibly modify the shoreline environment. Regulating land use to prevent structural encroachment into the erosive zone would come within these criteria and standards. However, such regional plan, by necessity, would be broad in scope and general in concept and probably would not contain a detailed inventory of the erosion characteristics of the shoreline. Therefore, the shoreline program presented herein includes a provision for a detailed study of the shoreline with respect to its erosive character so that definitive guidelines could be established for the non-structural reduction of potential future erosion damages.

At the Federal level, several bills have been introduced in Congress that would establish a policy of Federal participation with regard to the conservation and development of the Nation's coastal resources.

ACQUISITION OF RECREATIONAL SHORELINE

The program provides for acquisition and development of 10 miles of swimming beach within San Francisco Bay. Additional non-swimming beach would be made available through recreational use of shoreline that is presently publicly owned, but closed to public use. Other non-swimming beach would be made available as an incidental part of newly acquired scenic shoreline.

The program for acquisition of scenic shoreline for public recreational use in the San Francisco Bay subregion must be satisfied on the coastal shoreline, since none of the bay shoreline meets National Park Service criteria for natural scenic shoreline. The program involves acquisition of about 34 miles of the shoreline by the year 1980 and includes acquisition of virtually all of the remaining prime scenic shoreline along the subregion coast. Early acquisition for public use of this invaluable shoreline resource is proposed in order to prevent appropriation by private interests for conflicting shoreline uses. Acquisition will provide complete public control and management of such areas and result in substantial reductions in shoreline erosion damages.

EFFECTIVENESS OF THE SHORELINE PROGRAM

As indicated in the tabulation on page SF-31, average annual shoreline erosion damages for the San Francisco Bay subregion will increase from about $1.4 million in 1965 to $2.1 million by 1980, $3.9 million by 2000, and $4.7 million by 2020, if no measures to prevent erosion damages are implemented after 1965. If the shoreline program presented herein is fully implemented, the average annual residual

shoreline erosion damages will decrease from about $1.4 million in 1965 to $1.2 million by 1980, $1.0 million by 2000, and $0.8 million by 2020, as shown in Table SF-2. The overall reduction of the potential average annual shoreline damages due to full implementation of the shoreline program amounts to about $0.9 million by 1980, $2.9 million by 2000 and $3.9 million by 2020. Table SF-2 summarizes the effectiveness of the shoreline protection and development program in reducing shoreline erosion damages in the subregion.

Publicly-owned recreational shoreline in the San Francisco Bay subregion would increase from 53 shoreline miles to 82 shoreline miles to meet swimming and non-swimming beach demands during the study period. Of the total beach shoreline in the year 2020, 16 miles of swimming beach will be available along the bay shoreline, an increase of 12 miles in addition to the 4 miles of beach shoreline now available for swimming. As indicated in Table SF-1 approximately 2 miles of beach will be made available by beach replenishment and 10 miles will be newly-created swimming beaches, either incidental to shoreline erosion control projects or as separately authorized development projects. The overall total of 16 miles of swimming beach and 66 miles of non-swimming beach in the subregion will be adequate to meet requirements during the study period. Although some counties will not have adequate facilities to meet their local requirements, the facilities available will meet overall requirements within the subregion.

The total scenic shoreline requirement of 65 miles for the year 2020 will be met by the year 1980. This will require the acquisition of about 34 additional miles of shoreline during the time frame 1966-1980. Of the total additional requirement, about 28 miles will be acquired as a part of the Point Reyes National Seashore project in Marin County, about 6 miles will be acquired in the southerly part of San Mateo County and none will be acquired in either Sonoma or San Francisco Counties. All of the scenic shoreline acquisition will be along the subregion's coast. Table SF-3 summarizes the extent of the shoreline available by types of shoreline and by time frames, if the program is implemented.

Implementation

BASES FOR COST ESTIMATES

Estimates of cost for the shoreline protection and development program in the San Francisco Bay subregion were based to a large extent on data from available reports and current studies, adjusted to reflect particular site conditions. Reconnaissance-scope estimates were made when existing data were not available. In general, unit costs were developed for each subregion for structural measures and applied to sites with similar characteristics. Estimated costs for acquisition

of recreational shoreline were based upon prevailing land values for the particular area. The extent of each scenic shoreline site was determined by its scenic value and topography. Costs associated with non-structural measures to reduce potential future shoreline erosion damages were based on the estimated cost of studies needed to establish necessary guidelines for regulation of land use within the shoreline erosive zone.

ESTIMATED SHORELINE PROGRAM COSTS

The estimated installation costs for the shoreline protection and development program in the San Francisco Bay subregion amount to about $24.0 million for the 1966-1980 time frame, $16.7 million for the 1981-2000 time frame, and $10.7 million for the 2001-2020 time frame. These cost estimates do not include expenditures for access roads, or parking and sanitary facilities, which are included in Appendix XII: Recreation, under the general categories of development and acquisition costs for recreation land Classes I and II. Cumulative annual maintenance cost estimates amount to $350,000, $690,000 and $950,000 for the respective time frames. All maintenance costs are the responsibility of non-Federal interest, with the exception of maintenance costs associated with the Point Reyes National Seashore.

Table SF-4 summarizes the shoreline protection and development program costs for the San Francisco Bay subregion.

TABLE SF-1
SAN FRANCISCO BAY SUBREGION
Potential Projects, in Miles

Item	1966-1980	1981-2000	2001-2020	Program Total
COASTAL SHORELINE				
Marin County				
Beach Stabilization	1.1	0	0	1.1
Seawalls	0	0	0	0
Beach Replenishment	0	0	0.5	0.5
Beach Development	0	0	0	0
San Francisco County				
Beach Stabilization	0	1.5	0	1.5
Seawalls	0	0.7	0.5	1.2
Beach Replenishment	0	1.0	0	1.0
Beach Development	0	0	0	0
San Mateo County				
Beach Stabilization	0.9	0.5	1.0	2.4
Seawalls	1.0	0.6	0.5	2.1
Beach Replenishment	0	0	0.5	0.5
Beach Development	0	0	0	0
COASTAL SHORELINE TOTAL				
Beach Stabilization	2.0	2.0	1.0	5.0
Seawalls	1.0	1.3	1.0	3.3
Beach Replenishment	0	1.0	1.0	2.0
Beach Development	0	0	0	0

Continued

TABLE SF-1--Continued
SAN FRANCISCO BAY SUBREGION
Potential Projects, in Miles

Item	1966-1980	1981-2000	2001-2020	Program Total
BAY SHORELINE				
Marin County				
Beach Stabilization	0	0	0	0
Seawalls	0	0	0.5	0.5
Beach Replenishment	0	0	0	0
Beach Development	0	0	1.0	1.0
Solano County				
Beach Stabilization	0	0	0	0
Seawalls	0	0	0	0
Beach Replenishment	0	0	0	0
Beach Development	0	1.0	2.0	3.0
Contra Costa County				
Beach Stabilization	0	0	0	0
Seawalls	0	0	0.5	0.5
Beach Replenishment	0	0	0	0
Beach Development	0	0	1.0	1.0
Alameda County				
Beach Stabilization	2.0	1.0	0.5	3.5
Seawalls	0	0	0	0
Beach Replenishment	1.0	0	0	1.0
Beach Development	0	1.0	0	1.0

Continued

TABLE SF-1--Continued
SAN FRANCISCO BAY SUBREGION
Potential Projects, in Miles

Item	1966-1980	1981-2000	2001-2020	Program Total
BAY SHORELINE (continued)				
Santa Clara County				
Beach Stabilization	0	0	0	0
Seawalls	0	0	0	0
Beach Replenishment	0	0	0	0
Beach Development	0	0	1.0	1.0
San Mateo County				
Beach Stabilization	0	0	0.5	0.5
Seawalls	0	0	0	0
Beach Replenishment	0	0	0	0
Beach Development	1.0	1.0	0	2.0
San Francisco County				
Beach Stabilization	0	0	0	0
Seawalls	0	0.7	0	0.7
Beach Replenishment	0	0	0	0
Beach Development	1.0	0	0	1.0
BAY SHORELINE TOTAL				
Beach Stabilization	2.0	1.0	1.0	4.0
Seawalls	0	0.7	1.0	1.7
Beach Replenishment	1.0	0	0	1.0
Beach Development	2.0	3.0	5.0	10.0
SUBREGION TOTAL				
Beach Stabilization	4.0	3.0	2.0	9.0
Seawalls	1.0	2.0	2.0	5.0
Beach Replenishment	1.0	1.0	1.0	3.0
Beach Development	2.0	3.0	5.0	10.0

TABLE SF-2A

SAN FRANCISCO BAY SUBREGION--COASTAL SHORELINE

Estimated Average Annual Shoreline Erosion Damages and Damage Reduction through Shoreline Program, in $1,000 (1965 prices)

Item	Sonoma County	Marin County	San Francisco County	San Mateo County	Subregion (coastal)
Average annual damages, 1965	75	150	250	525	1,000
Average annual damage by 1980 with no shoreline program	93	254	462	891	1,700
Reduction in damage with 1966 to 1980 shoreline program					
Structural measures	0	144	0	196	340
Non-structural measures	50	50	120	260	480
Program total	50	194	120	456	820
Residual annual damage in 1980	43	60	342	435	880
Average annual damage by 2000 with no shoreline program after 1980	60	85	490	625	1,260
Reduction in damage with 1981 to 2000 shoreline program					
Structural measures	0	0	290	130	420
Non-structural measures	7	27	0	56	90
Program total	7	27	290	186	510
Residual annual damage in 2000	53	58	200	439	750
Average annual damage by 2020 with no shoreline program after 2000	60	70	240	520	890
Reduction in damage with 2001 to 2020 shoreline program					
Structural measures	0	15	35	120	170
Non-structural measures	1	3	0	6	10
Program total	1	18	35	126	180
Residual annual damage in 2020	59	52	205	394	710
Estimated annual damage in 2020 with no shoreline program after 1965, coastal shoreline	160	640	1,250	2,250	4,300
Total reduction in annual damage due to 1966 to 2020 shoreline program, coastal shoreline	101	588	1,045	1,856	3,590

Note: Totals for subregion are shown on Table SF-2B.

TABLE SF-2B

SAN FRANCISCO BAY SUBREGION--BAY SHORELINE

Estimated Average Annual Shoreline Erosion Damages and Damage Reduction through Shoreline Program, in $1,000 (1965 prices)

Item	Sonoma County	Marin County	Solano County	Contra Costa County	Alameda County	Santa Clara County	San Mateo County	San Francisco County	Sub-region (bay)
Average annual damages, 1965	7	53	16	64	172	3	40	45	400
Average annual damage by 1980 with no shoreline program	7	53	16	64	172	3	40	45	400
Reduction in damage with 1966 to 1980 shoreline program									
Structural measures	0	0	0	0	82	0	4	4	90
Non-structural measures	0	0	0	0	0	0	0	0	0
Program total	0	0	0	0	82	0	4	4	90
Residual annual damage in 1980	7	53	16	64	90	3	36	41	310
Average annual damage by 2000 with no shoreline program after 1980	7	53	16	64	90	3	36	41	310
Reduction in damage with 1981 to 2000 shoreline program									
Structural measures	0	0	4	0	49	0	4	33	90
Non-structural measures	0	0	0	0	0	0	0	0	0
Program total	0	0	4	0	49	0	4	33	90
Residual annual damage in 2000	7	53	12	64	41	3	32	8	220
Average annual damage by 2020 with no shoreline program after 2000	7	53	12	64	41	3	32	8	220
Reduction in damage with 2001 to 2020 shoreline program									
Structural measures	0	26	3	25	23	1	22	0	100
Non-structural measures	0	0	0	0	0	0	0	0	0
Program total	0	26	3	25	23	1	22	0	100
Residual annual damage in 2020	7	27	9	39	18	2	10	8	120

Estimated annual damage in 2020 with no shoreline program after 1965, bay shoreline	400
Total reduction in annual damage due to 1966 to 2020 shoreline program, bay shoreline	280

TOTAL, SAN FRANCISCO BAY SUBREGION, COASTAL AND BAY SHORELINE

Estimated annual damage in 2020 with no shoreline program after 1965	4,700
Total reduction in annual damage due to 1966 to 2020 shoreline program	3,870

TABLE SF-3A

SAN FRANCISCO BAY SUBREGION--COASTAL SHORELINE

Estimated Recreational Shoreline Needed, and Recreational Shoreline Made Available by the Program, in Miles

Item	Sonoma County			Marin County			San Francisco County			San Mateo County			Subregion (coastal)		
	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline
Available in 1965	0	12.8	2.3	0	25.3	25.1	0	3.4	0	0	7.5	3.6	0	49.0	31.0
Needed by 1980	0	6.4	-	0	6.6	-	0	5.6	-	0	6.4	-	0	25.0	-
Deficiency (-) or surplus (+)	0	+6.4	-	0	+18.7	-	0	-2.2	-	0	+1.1	-	0	+24.0	-
1966-1980 program supply	0	0	0	0	11.1	28.1	0	0	0	0	0.9	5.9	0	12.0	34.0
Available in 1980 with program	0	12.8	2.3	0	36.4	53.2	0	3.4	0	0	8.4	9.5	0	61.0	65.0
Needed by 2000	0	10.2	-	0	11.3	-	0	6.3	-	0	11.2	-	0	39.0	-
Deficiency (-) or surplus (+)	0	+2.6	-	0	+25.1	-	0	-2.9	-	0	-2.8	-	0	+22.0	-
1981-2000 program supply	0	0	0	0	0	0	0	1.5	0	0	0.5	0	0	2.0	0
Available in 2000 with program	0	12.8	2.3	0	36.4	53.2	0	4.9	0	0	8.9	9.5	0	63.0	65.0
Needed by 2020	0	14.0	-	0	18.0	-	0	7.0	-	0	18.0	-	0	57.0	-
Deficiency (-) or surplus (+)	0	-1.2	-	0	+18.4	-	0	-2.1	-	0	-9.1	-	0	+6.0	-
2001-2020 program supply	0	0	0	0	0	0	0	0	0	0	1.0	0	0	1.0	0
Available in 2020 with program	0	12.8	2.3	0	36.4	53.2	0	4.9	0	0	9.9	9.5	0	64.0	65.0
Needed by 2020	0	14.0	-	0	18.0	-	0	7.0	-	0	18.0	-	0	57.0	-
Deficiency (-) or surplus (+) at end of program	0	-1.2	-	0	+18.4	-	0	-2.1	-	0	-8.1	-	0	+7.0	-

TABLE SF-3B

SAN FRANCISCO BAY SUBREGION--BAY SHORELINE[1/]

Estimated Recreational Shoreline Needed, and Recreational Shoreline Made Available by the Program, in Miles

Item	Marin County		Solano County		Contra Costa County		Alameda County		Santa Clara County		San Mateo County		San Francisco County		Subregion (bay)	
	Swimming beach	Non-swimming beach	Swimming beach	Non-swimming beach	Swimming beach	Non-swimming beach	Swimming beach	Non-swimming beach	Swimming beach	Non-swimming beach	Swimming beach	Non-swimming beach	Swimming beach	Non-swimming beach	Swimming beach	Non-swimming beach
Available in 1965	0.2	0	0	0	0.4	0	2.8	0	0	0	0.2	0	0.4	0	4.0	0
Needed by 1980	0.6	0.2	0.1	0	0.9	0.1	3.0	0.3	0.2	0	1.8	0.3	0.4	0.1	7.0	1.0
Deficiency (-) or surplus (+)	-0.4	-0.2	-0.1	0	-0.5	-0.1	-0.2	-0.3	-0.2	0	-1.6	-0.3	0	-0.1	-3.0	-1.0
1966-1980 program supply	0	0	0	0	0	0	1.0	1.0	0	0	1.0	0	1.0	0	3.0	1.0
Available in 1980 with program	0.2	0	0	0	0.4	0	3.8	1.0	0	0	1.2	0	1.4	0	7.0	1.0
Needed by 2000	0.7	0.2	0.2	0	1.5	0.1	3.5	0.3	0.4	0	4.3	0.3	0.4	0.1	11.0	1.0
Deficiency (-) or surplus (+)	-0.5	-0.2	-0.2	0	-1.1	-0.1	+0.3	+0.7	-0.4	0	-3.1	-0.3	+1.0	-0.1	-4.0	0
1981-2000 program supply	0	0	1.0	0	0	0	2.0	0	0	0	1.0	0	0	0	4.0	0
Available in 2000 with program	0.2	0	1.0	0	0.4	0	5.8	1.0	0	0	2.2	0	1.4	0	11.0	1.0
Needed by 2020	0.8	0.3	0.8	0.1	2.2	0.2	5.4	0.6	0.6	0.1	5.8	0.6	0.4	0.1	16.0	2.0
Deficiency (-) or surplus (+)	-0.6	-0.3	+0.2	-0.1	-1.8	-0.2	+0.4	+0.4	-0.6	-0.1	-3.6	-0.6	+1.0	-0.1	-5.0	-1.0
2001-2020 program supply	1.0	0	1.0	1.0	1.0	0	0.5	0	1.0	0	0.5	0	0	0	5.0	1.0
Available in 2020 with program	1.2	0	2.0	1.0	1.4	0	6.3	1.0	1.0	0	2.7	0	1.4	0	16.0	2.0
Needed by 2020	0.8	0.3	0.8	0.1	2.2	0.2	5.4	0.6	0.6	0.1	5.8	0.6	0.4	0.1	16.0	2.0
Deficiency (-) or surplus (+) at end of program	+0.4	-0.3	+1.2	+0.9	-0.8	-0.2	+0.9	+0.4	+0.4	-0.1	-3.1	-0.6	+1.0	-0.1	0	0

1/ *Applicable values for Napa and Sonoma counties are zero.*

TABLE SF-4A*

SAN FRANCISCO BAY SUBREGION -- COASTAL SHORELINE

Estimated Shoreline Program Costs, in $1,000 (1965 prices)

1966-1980 PROGRAM

Item	Sonoma County	Marin County	San Francisco County	San Mateo County	Coastal Subtotal	Bay Subtotal	Subregion Total
STRUCTURAL MEASURES:							
Installation costs							
Federal	0	2,300	0	3,200	5,500	700	6,200
Non-Federal	0	2,300	0	3,200	5,500	2,000	7,500
Subtotal	0	4,600	0	6,400	11,000	2,700	13,700
Annual OM & R							
Federal	0	0	0	0	0	0	0
Non-Federal	0	74	0	86	160	90	250
Subtotal	0	74	0	86	160	90	250
NON-STRUCTURAL MEASURES:							
Installation costs							
Federal	0	8,400	0	0	8,400	0	8,400
Non-Federal	17	1,870	8	55	1,950	0	1,950
Subtotal	17	10,270	8	55	10,350	0	10,350
Annual OM & R							
Federal	0	80	0	0	80	0	80
Non-Federal	0	20	0	0	20	0	20
Subtotal	0	100	0	0	100	0	100
1966-1980 PROGRAM							
Federal	0	10,700	0	3,200	13,900	700	14,600
Non-Federal	17	4,170	8	3,255	7,450	2,000	9,450
Total	17	14,870	8	6,455	21,350	2,700	24,050
Annual OM & R	0	174	0	86	260	90	350

*See Table SF-4B.

Continued

TABLE SF-4A*--Continued

SAN FRANCISCO BAY SUBREGION -- COASTAL SHORELINE

Estimated Shoreline Program Costs, in $1,000 (1965 prices)

Item	Sonoma County	Marin County	San Francisco County	San Mateo County	Coastal Subtotal	Bay Subtotal	Subregion Total
1981-2000 PROGRAM							
STRUCTURAL MEASURES:							
Installation costs							
Federal	0	0	4,900	2,000	6,900	750	7,650
Non-Federal	0	0	4,900	2,000	6,900	1,950	8,850
Subtotal	0	0	9,800	4,000	13,800	2,700	16,500
Annual OM & R							
Federal	0	0	0	0	0	0	0
Non-Federal	0	0	197	63	260	80	340
Subtotal	0	0	197	63	260	80	340
NON-STRUCTURAL MEASURES:							
Installation costs							
Federal	0	0	0	0	0	0	0
Non-Federal	17	70	8	55	150	0	150
Subtotal	17	70	8	55	150	0	150
Annual OM & R							
Federal	0	0	0	0	0	0	0
Non-Federal	0	0	0	0	0	0	0
Subtotal	0	0	0	0	0	0	0
1981-2000 PROGRAM TOTAL							
Federal	0	0	4,900	2,000	6,900	750	7,650
Non-Federal	17	70	4,908	2,055	7,050	1,950	9,000
Total	17	70	9,808	4,055	13,950	2,700	16,650
Annual OM & R	0	0	197	63	260	80	340

*See Table SF-4B.

Continued

TABLE SF-4A*--Continued

SAN FRANCISCO BAY SUBREGION -- COASTAL SHORELINE

Estimated Shoreline Program Costs, in $1,000 (1965 prices)

2001-2020 PROGRAM

Item	Sonoma County	Marin County	San Francisco County	San Mateo County	Coastal Subtotal	Bay Subtotal	Subregion Total
STRUCTURAL MEASURES:							
Installation costs							
Federal	0	200	500	2,950	3,650	900	4,550
Non-Federal	0	200	500	2,950	3,650	2,500	6,150
Subtotal	0	400	1,000	5,900	7,300	3,400	10,700
Annual OM & R							
Federal	0	0	0	0	0	0	0
Non-Federal	0	20	10	120	150	110	260
Subtotal	0	20	10	120	150	110	260
NON-STRUCTURAL MEASURES:							
Installation costs							
Federal	0	0	0	0	0	0	0
Non-Federal	17	70	8	55	150	0	150
Subtotal	17	70	8	55	150	0	150
Annual OM & R							
Federal	0	0	0	0	0	0	0
Non-Federal	0	0	0	0	0	0	0
Subtotal	0	0	0	0	0	0	0
2001-2020 PROGRAM TOTAL							
Federal	0	200	500	2,950	3,650	900	4,550
Non-Federal	17	270	508	3,005	3,800	2,500	6,300
Total	17	470	1,008	5,955	7,450	3,400	10,850
Annual OM & R	0	20	10	120	150	110	260

*See Table SF-4B.

TABLE SF-4B*

SAN FRANCISCO BAY SUBREGION -- BAY SHORELINE

Estimated Shoreline Program Costs, in $1,000 (1965 prices)

1966-1980 PROGRAM

Item	Marin County	Solano County	Contra Costa County	Alameda County	Santa Clara County	San Mateo County	San Francisco County	Bay Subtotal	Coastal Subtotal	Subregion Total
STRUCTURAL MEASURES:										
Installation costs										
Federal	0	0	0	700	0	0	0	700	5,500	6,200
Non-Federal	0	0	0	1,200	0	400	400	2,000	5,500	7,500
Subtotal	0	0	0	1,900	0	400	400	2,700	11,000	13,700
Annual OM & R										
Federal	0	0	0	0	0	0	0	0	0	0
Non-Federal	0	0	0	50	0	20	20	90	160	250
Subtotal	0	0	0	50	0	20	20	90	160	250
NON-STRUCTURAL MEASURES:										
Installation costs										
Federal	0	0	0	0	0	0	0	0	8,400	8,400
Non-Federal	0	0	0	0	0	0	0	0	1,950	1,950
Subtotal	0	0	0	0	0	0	0	0	10,350	10,350
Annual OM & R										
Federal	0	0	0	0	0	0	0	0	80	80
Non-Federal	0	0	0	0	0	0	0	0	20	20
Subtotal	0	0	0	0	0	0	0	0	100	100
1966-1980 PROGRAM TOTAL										
Federal	0	0	0	700	0	0	0	700	13,900	14,600
Non-Federal	0	0	0	1,200	0	400	400	2,000	7,450	9,450
Total	0	0	0	1,900	0	400	400	2,700	21,350	24,050
Annual OM & R	0	0	0	50	0	20	20	90	260	350

*See Table SF-4A.

Continued

TABLE SF-4B*--Continued

SAN FRANCISCO BAY SUBREGION -- BAY SHORELINE

Estimated Shoreline Program Costs, in $1,000 (1965 prices)

1981-2000 PROGRAM

Item	Solano County	Alameda County	San Mateo County	San Francisco County	Bay Subtotal	Coastal Subtotal	Subregion Total
STRUCTURAL MEASURES:							
Installation costs							
Federal	0	400	0	350	750	6,900	7,650
Non-Federal	400	800	400	350	1,950	6,900	8,850
Subtotal	400	1,200	400	700	2,700	13,800	16,500
Annual OM & R							
Federal	0	0	0	0	0	0	0
Non-Federal	20	33	20	7	80	260	340
Subtotal	20	33	20	7	80	260	340
NON-STRUCTURAL MEASURES:							
Installation costs							
Federal	0	0	0	0	0	0	0
Non-Federal	0	0	0	0	0	150	150
Subtotal	0	0	0	0	0	150	150
Annual OM & R							
Federal	0	0	0	0	0	0	0
Non-Federal	0	0	0	0	0	0	0
Subtotal	0	0	0	0	0	0	0
1981-2000 PROGRAM TOTAL							
Federal	0	400	0	350	750	6.900	7,650
Non-Federal	400	800	400	350	1,950	7,050	9,000
Total	400	1,200	400	700	2,700	13,950	16,650
Annual OM & R	20	33	20	7	80	260	340

*See Table SF-4A.

Note: Marin, Contra Costa, and Santa Clara Counties have no shoreline costs in this time frame.

Continued

TABLE SF-4B*--Continued

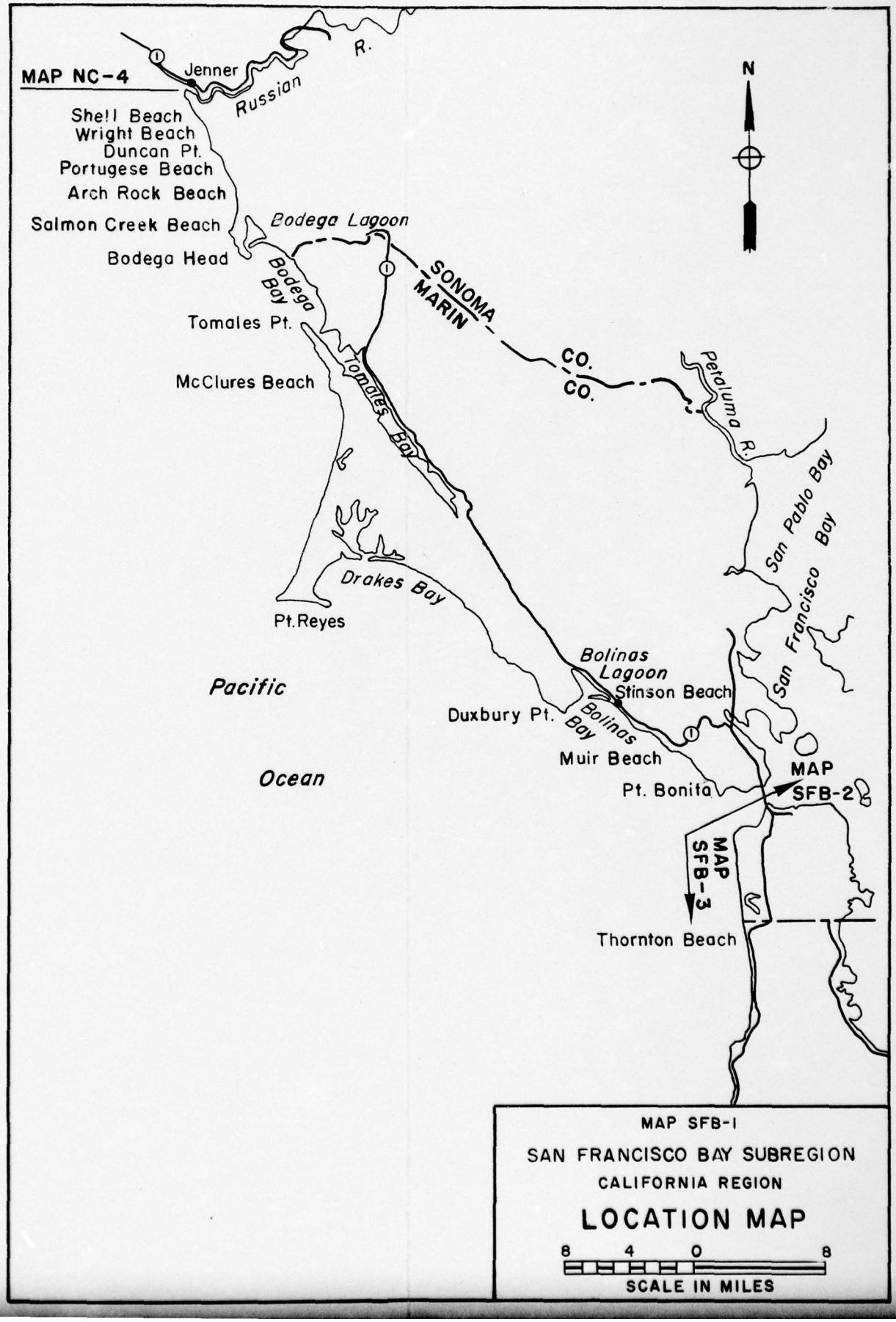
SAN FRANCISCO BAY SUBREGION -- BAY SHORELINE

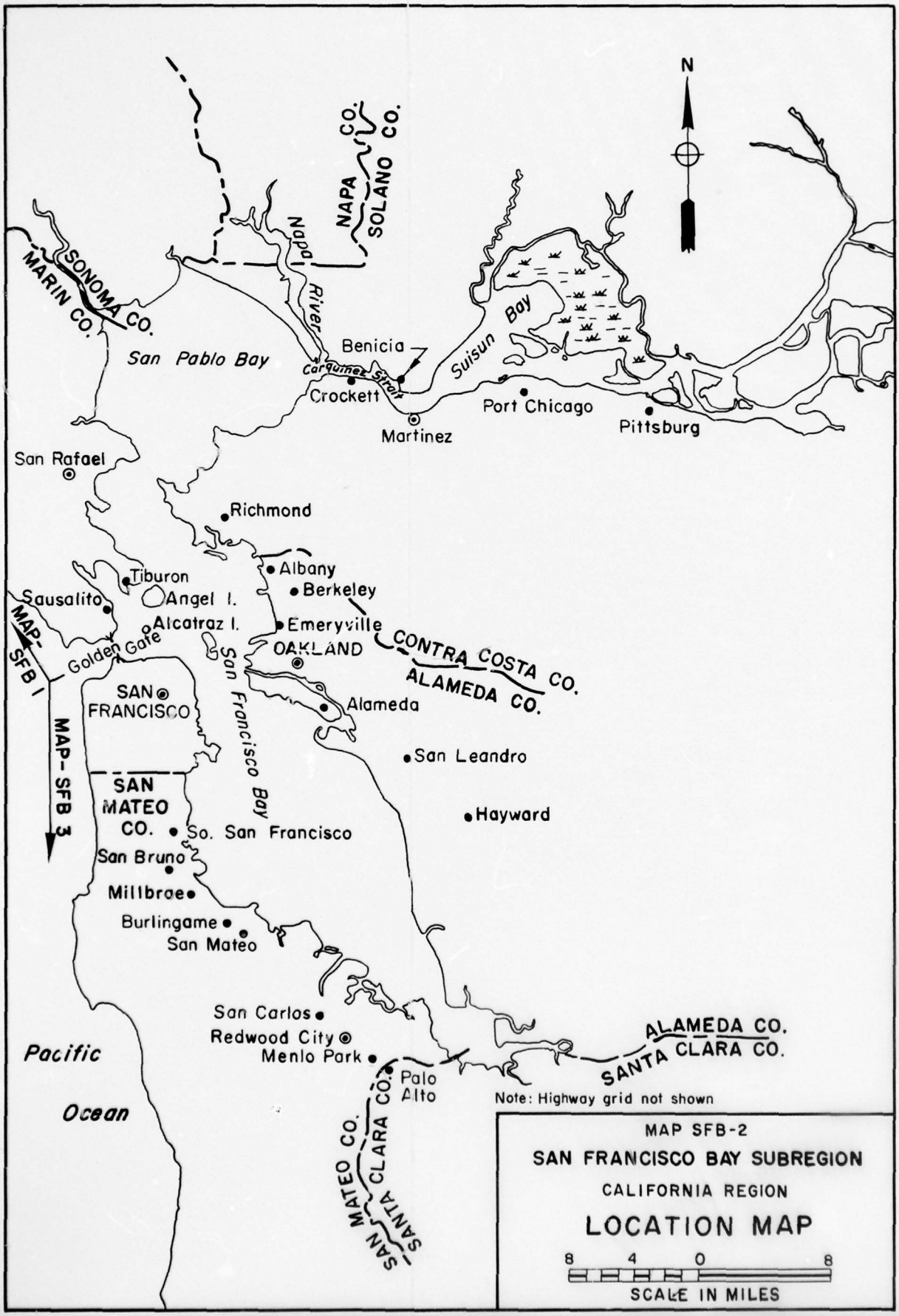
Estimated Shoreline Program Costs, in $1,000 (1965 prices)

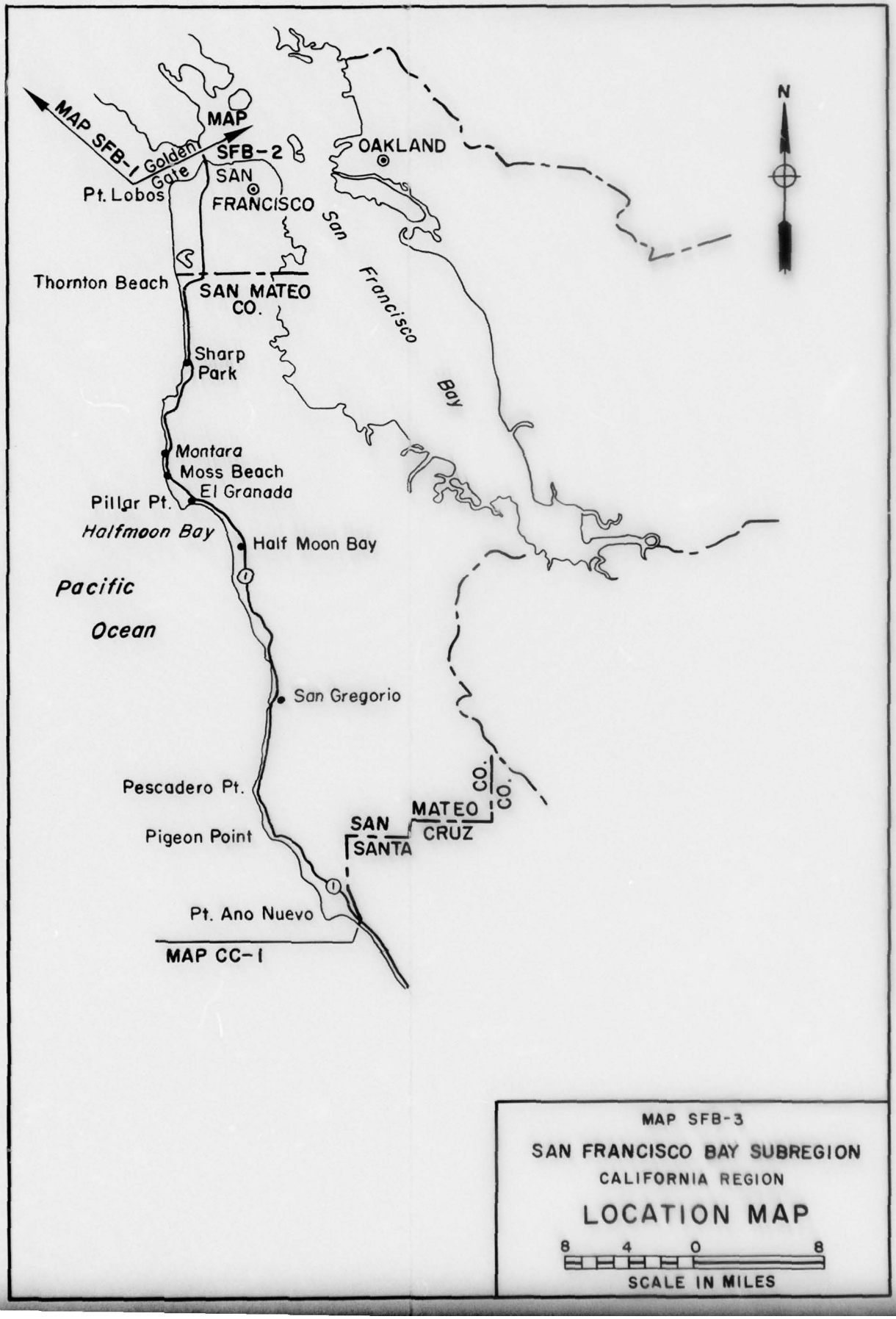
Item	Marin County	Solano County	Contra Costa County	Alameda County	Santa Clara County	San Mateo County	Bay Subtotal	Coastal Subtotal	Subregion Total
	2001-2020 PROGRAM								
STRUCTURAL MEASURES:									
Installation costs									
Federal	250	0	250	200	0	200	900	3,650	4,550
Non-Federal	550	700	550	200	300	200	2,500	3,650	6,150
Subtotal	800	700	800	400	300	400	3,400	7,300	10,700
Annual OM & R									
Federal	0	0	0	0	0	0	0	0	0
Non-Federal	21	32	21	10	16	10	110	150	260
Subtotal	21	32	21	10	16	10	110	150	260
NON-STRUCTURAL MEASURES:									
Installation costs									
Federal	0	0	0	0	0	0	0	0	0
Non-Federal	0	0	0	0	0	0	0	150	150
Subtotal	0	0	0	0	0	0	0	150	150
Annual OM & R									
Federal	0	0	0	0	0	0	0	0	0
Non-Federal	0	0	0	0	0	0	0	0	0
Subtotal	0	0	0	0	0	0	0	0	0
2001-2020 PROGRAM TOTAL									
Federal	250	0	250	200	0	200	900	3,650	4,550
Non-Federal	550	700	550	200	300	200	2,500	3,800	6,300
Total	800	700	800	400	300	400	3,400	7,450	10,850
Annual OM & R	21	32	21	10	16	10	110	150	260

*See Table SF-4A.

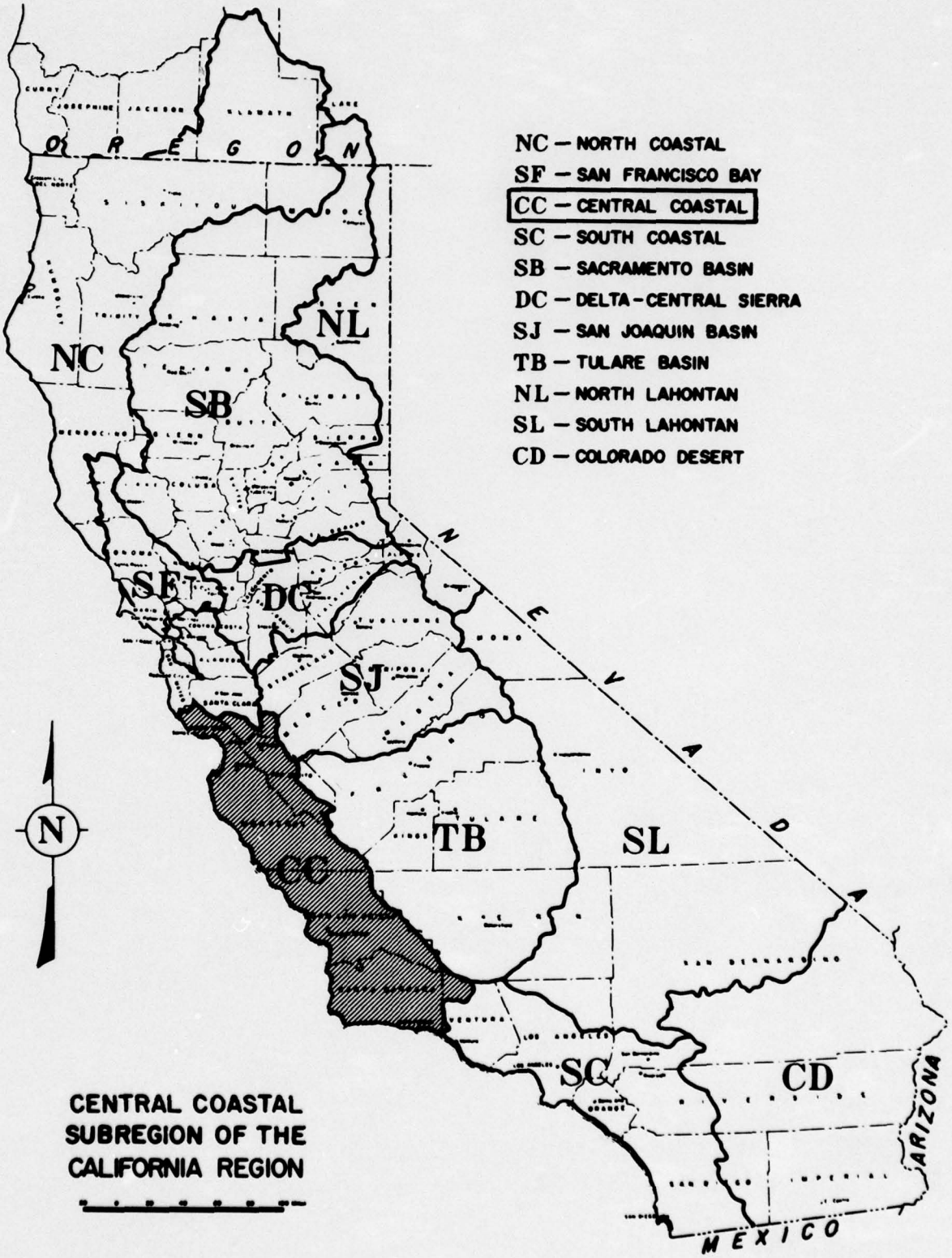
Note: San Francisco County has no program costs during this time frame.


MAP NC-4
Jenner
Russian R.
Shell Beach
Wright Beach
Duncan Pt.
Portugese Beach
Arch Rock Beach
Salmon Creek Beach
Bodega Head
Bodega Lagoon
Bodega Bay
Tomales Pt.
McClures Beach
SONOMA CO.
MARIN CO.
Petaluma R.
Tomales Bay
Drakes Bay
Pt. Reyes
Pacific
Ocean
San Pablo Bay
San Francisco Bay
Bolinas Lagoon
Stinson Beach
Duxbury Pt.
Bolinas Bay
Muir Beach
Pt. Bonita
MAP SFB-2
MAP SFB-3
Thornton Beach
N
MAP SFB-1
SAN FRANCISCO BAY SUBREGION
CALIFORNIA REGION
LOCATION MAP
8 4 0 8
SCALE IN MILES


N
NAPA CO.
SOLANO CO.
SONOMA CO.
MARIN CO.
Napa River
San Pablo Bay
Carquinez Strait
Benicia
Crockett
Martinez
Suisun Bay
Port Chicago
Pittsburg
San Rafael
Richmond
Albany
Berkeley
Tiburon
Angel I.
Sausalito
Alcatraz I.
Emeryville
OAKLAND
CONTRA COSTA CO.
ALAMEDA CO.
Golden Gate
MAP-SFB 1
SAN FRANCISCO
San Francisco Bay
Alameda
San Leandro
MAP-SFB 3
SAN MATEO CO.
So. San Francisco
Hayward
San Bruno
Millbrae
Burlingame
San Mateo
San Carlos
Redwood City
Menlo Park
Palo Alto
ALAMEDA CO.
SANTA CLARA CO.
Pacific Ocean
SAN MATEO CO.
SANTA CLARA CO.
Note: Highway grid not shown
MAP SFB-2
SAN FRANCISCO BAY SUBREGION
CALIFORNIA REGION
LOCATION MAP
8 4 0 8
SCALE IN MILES


MAP SFB-1
Golden Gate
MAP SFB-2
OAKLAND
SAN FRANCISCO
Pt. Lobos
San Francisco Bay
Thornton Beach
SAN MATEO CO.
Sharp Park
Montara
Moss Beach
El Granada
Pillar Pt.
Halfmoon Bay
Half Moon Bay
Pacific Ocean
San Gregorio
Pescadero Pt.
Pigeon Point
SAN MATEO CO.
SANTA CRUZ CO.
Pt. Ano Nuevo
MAP CC-1
N
MAP SFB-3
SAN FRANCISCO BAY SUBREGION
CALIFORNIA REGION
LOCATION MAP
8 4 0 8
SCALE IN MILES

CENTRAL COASTAL SUBREGION



CENTRAL COASTAL SUBREGION OF THE CALIFORNIA REGION

CENTRAL COASTAL SUBREGION

Description of the Subregion

PHYSICAL CHARACTERISTICS

The Central Coastal subregion includes the coastal counties of Santa Cruz, Monterey, San Luis Obispo and Santa Barbara; as well as portions of Santa Clara, San Benito and inland Ventura County. The mainland ocean shoreline of the subregion is 356 miles long. Three offshore islands are within Santa Barbara County. These islands are Santa Cruz, Santa Rosa and San Miguel; and together they have about 188 miles of shoreline. The configuration of the mainland subregion is shown the opposite index map.

The subregion is generally mountainous and rugged. Various mountain ranges, which generally parallel the coast, are the Coast Range, the Santa Lucia Range, the Sierra Madre, and the San Rafael and Santa Ynez Mountains. Major streams in the subregion include the San Lorenzo, San Benito, Pajaro, Salinas, Santa Maria and Santa Ynez Rivers. The Salinas River runs through the largest of the intermountain valleys of the Coast Range; this valley is about 10 miles wide near the coast. The other river valleys are narrower. Except for these river valleys, the subregion has little or no coastal plain. Throughout most of the subregion, mountainous terrain and rolling hills extend out to the shoreline, producing a rugged coast with considerable scenic significance. The subregion has one natural bay, Morro Bay, which has a water area of 3.5 square miles at mean high water.

The 600-foot contour of the continental shelf lies from 1 to 15 miles offshore, and the 10-fathom depth is about 2 miles offshore through the subregion. Three major submarine canyons cut the continental shelf in the northern half of the subregion; the Monterey canyon is located near the middle of Monterey Bay, the Carmel canyon is near the mouth of the Carmel River, and the Lucia canyon is just upcoast from Cape San Martin. In the southern part of the subregion, the edge of the shelf is notched in several areas, but no major canyons penetrate toward shore.

CLIMATE AND EXPOSURE

Climate and exposure in the southern part of the subregion below Point Conception are identical in all respects to the climate and exposure in the South Coastal subregion. (See page SC-1). The abrupt change in alignment of the coast at Point Conception produces a marked change in climate, water temperature and exposure to wave action. The climate north of Point Conception is characterized by mild summers marked by considerable coastal fog. The average annual temperature in Salinas, which is typical

of the subregion, is about 56° F; the average maximum temperature is 67° and the average minimum is 46°. The ocean waters of the subregion south of Point Conception are warm enough for water-contact sports through much of the year. North of Point Conception, water temperatures are markedly colder, with a summer mean of about 60°. Ocean bathing is attractive in relatively few areas, and then only during the mid-summer months.

Rainfall occurs almost exclusively during the winter months. Average annual rainfall ranges from almost 30 inches to about 17 inches. Generally, annual rainfall decreases from north to south. Severe winds are unusual; the typical regime consists of a diurnal system of offshore and onshore breezes with a mean speed of about 8.6 knots. Fogs are thick and persistent in many areas.

Ocean waves reaching the coast of the Central Coastal subregion can be classified as northern hemisphere swell, southern hemisphere swell, and sea. Swell and sea are terms given to waves generated by distant and local winds, respectively. Southern hemisphere swells are of relatively minor significance north of Point Conception as compared to the north hemisphere swell and seas resulting from the prevailing northwesterly winds. The coastline generally is oriented parallel to the direction of approaching wave fronts. Much of the shoreline is subject to high breakers that produce wide surf zones and gently sloping beaches.

POPULATION DISTRIBUTION

The Central Coastal subregion had a population of about 687,000 in 1965, which was approximately 3.8 percent of the total population of the California Region. About half of the subregion's population lived in cities with a population of over 10,000. The largest cities in the subregion in 1965 were Santa Barbara, Salinas and Santa Maria, with populations of about 70,000; 52,000; and 31,000, respectively. These three cities are all within 10 miles of the coast. Residents of the San Francisco Bay, South Coastal, and interior subregions comprise a significant part of the shoreline visitors. The projected subregion population is 1,066,000 in 1980; 2,080,000 in 2000; and 4,063,000 in 2020. The 2020 subregion population represents about 7.3 percent of the projected total population of the California Region.

ECONOMY

The principal economic activities of the subregion center around tourism and agriculture. The subregion also has a number of large military reservations; the armed forces represented over 11 percent of the total work force in 1965. The subregion has varied recreational resources, including beaches, redwood groves, and scenic shoreline; and several important resort areas, such as Monterey Peninsula, Santa Cruz and Santa Barbara. Over 70 percent of the total civilian employment was in the service sector in 1965, underscoring the importance of recreation and tourism to the subregion. The subregion also has some of the finest crop land in the California Region,

and the agricultural sector accounts for about 14 percent of the civilian employment. However, future employment in this sector will decrease to approach the regional percentage, presently 4 percent, as farming becomes more mechanized and small farms are integrated into larger, more efficient units.

TRANSPORTATION

The subregion is served by a transportation system that includes a major north-south interstate highway, which is generally inland from the coast; a State coast highway; connecting State, county and local roads; and railroad, bus and air service.

State Highway No. 1 follows the shoreline quite closely from the subregion's north boundary to Morro Bay. From Morro Bay to Gaviota, where it joins U.S. Highway No. 101, State Highway No. 1 is somewhat inland except for a short reach along the coast near Pismo Beach. From Gaviota to the south boundary of the subregion, U.S. Highway No. 101 parallels the shoreline. Lateral State and local highways connect interior areas with U.S. Highway No. 101 and State Highway No. 1. Access to the shoreline between Morro Bay and Gaviota is limited, except at Pismo Beach. The Southern Pacific Company's railroad line connecting San Francisco and Los Angeles provides service to the subregion. Bus service is provided throughout the subregion; Monterey and Santa Barbara have commercial airports.

Existing Conditions in the Shoreline Zone

DESCRIPTION OF THE SHORELINE

General

Of the total of 356 miles of mainland shoreline, about 46 miles are considered to be non-eroding or stable, with the remaining 310 miles in varying degrees of erosion. Of the eroding shoreline, about 90 miles are eroding critically, threatening mainly highways, urban properties, and recreational swimming beaches. The rate of erosion for the Central Coastal subregion ranges from non-eroding to about 4 feet per year. The following paragraphs describe the shoreline topography and associated problems by counties, from north to south. Major locations are shown on Maps CC-1 through CC-4, at the end of this chapter.

Santa Cruz County

This county has a shoreline length of about 42 miles, or 12 percent of the total mainland shoreline of the subregion. From the San Mateo-Santa Cruz County line to the mouth of San Vicente Creek at Davenport, a distance of about 10 miles, the shoreline is generally steep. In the northern part of the segment, Big Basin Redwoods State Park and associated state-owned shoreline provides about 1.5 miles of attractive, wide, sandy beach in the

vicinity of Waddell Creek and Canyon; and about 2.5 miles of scenic rocky shoreline, including the Greyhound Rock State Fish and Game Reserve. An attractive lagoon, a wide level meadow, and a few offshore rocks enhance the recreational and biological values of this area. Inshore land use is agricultural; the upper part of Waddell Canyon is used for logging operations. The balance of the shoreline in this segment is privately owned. Toward Davenport Landing and the town of Davenport, the terrain becomes less rugged. The Davenport terminal on the Southern Pacific Railroad occupies a part of the widened shoreline plain in this vicinity. Both the railroad and State Highway No. 1 run parallel to the shoreline about 200 to 400 feet inshore. A small community of homes at Davenport is dependent upon a cement plant and related commercial activities to support the local economy. Shoreline development is negligible, except at Davenport. Critical erosion is threatening State Highway No. 1 in the vicinity of Waddell Creek. Erosion along the remainder of the reach is non-critical.

Between Davenport and Point Santa Cruz, a distance of about 13 miles, the shoreline is backed by seacliffs and bluffs varying from 40 to 80 feet in height. There are occasional narrow, rocky and sandy pocket beaches fronting the cliffs. The Southern Pacific Railroad and the State highway run parallel to the shoreline on top of these seacliffs and at the base of backshore bluffs. Natural Bridges State Park is located in the vicinity of the city of Santa Cruz and Point Santa Cruz. The shoreline terrain is extremely rugged and scenic; the sandy beach is decorated with wave-carved formations for which the park is named. Land use in the segment is primarily agricultural, with some recreational use and a few scattered residential areas. The densely populated urban area in the city of Santa Cruz begins about 1 mile upcoast from Point Santa Cruz. Critical erosion in the vicinity of Point Santa Cruz is threatening residences and local streets, and dumped rock has been placed by local interests to control the erosion. Erosion in other parts of the segment is non-critical.

From the Coast Guard Reservation at Point Santa Cruz to the community of Rio Del Mar is a distance of about 10 miles. The shoreline is urban and agricultural with numerous beaches, scenic drives, and State parks and beaches. The Santa Cruz swimming beaches in this reach include Cowell and Santa Cruz beaches, at the Santa Cruz Municipal Pier, which provide almost 1 mile of sandy beach frontage, overlooked by backshore seacliffs ranging in height up to 70 feet. The internationally-known Santa Cruz Boardwalk, about 1/2 mile long, extends parallel to the beach frontage, and is flanked by restaurants, shops, and related recreational and tourist enterprises and accommodations. Santa Cruz Harbor, a small-craft harbor, lies about 0.5 mile to the east. Other beaches include Twin Lakes Beach, Soquel Point Beach, Capitola Beach, New Brighton Beach, and Seacliffs Beach. These sandy beaches, suitable for swimming and other recreational uses, are backed by high eroded seacliffs. Critical erosion has been a serious and continuing problem in parts of this segment, and substantial construction -- including

riprap, seawalls, stone groins, placement of beach fill and other protective measures -- has been authorized by Congress. The overall Corps of Engineers construction program is about 30 percent complete. Seawall construction is about 80 percent complete. Dumped rock and concrete rubble have been used by local interests to protect critical erosion points, and owners of privately-owned shoreline adjacent to the Federal project have constructed seawalls of Corps of Engineers design. Critical erosion is also occurring between Twin Lakes Beach and New Brighton Beach State Park. Other erosion within the reach is not considered critical. The Southern Pacific railroad and State Highway No. 1 continue parallel to the shoreline and from 0.3 to 2 miles inshore.

From Rio Del Mar to the Santa Cruz-Monterey County line at the mouth of Pajaro River, a distance of about 9 miles, the shoreline is characterized by steep eroded seacliffs backing sandy beaches. Manresa and Sunset State beaches comprise about 6 miles of public recreational beach. The seacliffs terminate at the edge of the Pajaro Valley, about a mile north of the mouth of the river. Land use in this segment is agricultural, urban and recreational. Both the Southern Pacific railroad and State Highway No. 1, which run parallel to the shoreline, turn easterly through the City of Watsonville as they near the Pajaro Valley. Erosion is not critical in this reach.

Monterey County

Monterey County has a shoreline length of about 111 miles, or 31 percent of the subregion's mainland shoreline. The segment from the Santa Cruz-Monterey County line, at the mouth of the Pajaro River, to the community of Seaside, upcoast from the city of Monterey, is about 17 miles long. The shoreline in this segment is continuous sandy beach. Sand dunes comprise both the backshore of the beaches and the upland area behind the beaches. These dunes extend over 1/2 mile inland in places. South of the Salinas River, the backshore gradually rises, and small hills and terraces approach the shoreline. The beaches in the segment are windswept and unsheltered from the west, and are not suitable for swimming.

There are two State beaches (Zmudowski and Salinas River) with a shoreline length of about 2.8 miles. Slightly over 4 miles of the shoreline is in the Fort Ord Military Reservation. Untreated sewage discharged into the ocean from this reservation and from municipalities in the area has caused significant pollution of the beaches; the pollution has required that the beaches be closed to the public. The Monterey submarine canyon extends within 300 feet of the shoreline at Moss Landing, in the northerly part of this segment, and marks the entrance to Moss Landing Harbor. Elkhorn Slough, which has significant wildlife values, lies inland from the harbor. Land use is primarily agricultural, recreational and military.

State Highway No. 1 nears the shoreline at Moss Landing, then turns inland to pass through Castroville, returns to the shoreline near the mouth

of the Salinas River, and continues near the shoreline through the Fort Ord Military Reservation to the town of Seaside. The Southern Pacific railroad line runs along the backshore area to Castroville, then runs parallel to the state highway to Seaside and then turns toward the peninsula shoreline of Monterey and Asilomar.

Sand mining operations along the shoreline to the north and to the south of Fort Ord Military Reservation are extensive and have been estimated to amount to about one-quarter million tons per annum. The effect of sand mining operations on littoral transport cannot be evaluated due to lack of necessary basic data; however, it is to be noted that the Fort Ord shoreline in this reach is subject to critical erosion. Dumped rock has been placed at the foot of the seacliffs in this reach to provide necessary protection.

Downcoast from Seaside, the next 2.5 miles of shoreline comprises 2.0 miles of beach and 0.5 mile within Monterey Harbor. The community of Retreat and the northern part of the city of Monterey occupy the upland area. The beach is backed by shifting sand dunes; Monterey State Beach, which is about 0.4 mile long, and a small city-owned beach comprises the public beach.

The 22.5-mile-long segment from Monterey Harbor to Yankee Point Rock comprises the Monterey Peninsula. From Monterey, a scenic 17-mile-long toll road follows the edge of the peninsula to Carmel Bay. Asilomar Beach, which is rocky and rugged, and the internationally-known Asilomar convention and retreat area are located on the shoreline. Point Pinos Lighthouse, Point Joe, Cypress Point, the Pebble Beach Golf Course, Pebble Beach, Stillwater Cove, a wide variety of wildlife, and the beautiful scenery of this rugged and hilly peninsula may be viewed as the scenic drive continues along the shoreline to the white sands of Carmel Beach at Carmel by the Sea. The Carmel area is widely known for its scenic values. Just south of Carmel Beach, the Carmel Valley separates the hilly peninsula from a rugged mountain area and the Carmel Highlands. Upland elevations in this vicinity range to approximately 2,000 feet above mean sea level. Numerous offshore rocks mark both Carmel Point and Yankee Point. Carmel River State Beach, a sandy beach, is probably nourished by material carried into the littoral zone by the Carmel River; however, upstream developments may limit the volume of material transported, and starvation and erosion may become critical problems. The Carmel submarine canyon approaches close to the shoreline in this vicinity and the ocean floor drops off very rapidly offshore. The rapid dropoff detracts from the suitability of the beach for swimming. Offshore rocks in this vicinity are fewer than at either the Monterey Peninsula or Carmel and Yankee Points. Land use is recreational, residential, wildlife reserve, park and related purposes. The Carmel Peninsula is the location of the Point Lobos State Reserve. State Highway No. 1 and local roads provide access throughout the segment. Erosion currently is not critical in this reach.

The segment from Yankee Point Rock to Point Sur is about 15 miles long. The Soberanes Point area, from Malpaso Creek in the north to Rocky Point in the south, includes a 6-mile length of unusually scenic, rugged shoreline marked by exposed offshore rocks and reefs. The shoreline has been designated as a State refuge for the California sea otter. The area includes one small, sandy beach with a shoreline frontage of about 0.6 mile at the mouth of Doud Creek. Numerous scenic view sites are complemented by several relatively flat areas. Low tides expose a multitude of tidepools containing outstanding displays of marine life. From Rocky Point to Point Sur, the shoreline continues rugged. Offshore rocks are numerous, and beach areas are rocky and extremely narrow. A sandy beach at the mouth of Little Sur River includes a 1 mile frontage of coarse sandy shoreline. An attractive lagoon is located behind the beach, and the canyon behind the lagoon has many large redwood trees. The upland terrain throughout the entire reach is mountainous with elevations up to 2,300 feet. Land use is cattle grazing, reserve and recreational. Erosion is not critical, except in the vicinity of Castle Rock and Bixby Landing, where sections of State Highway No. 1 are threatened with erosion damage. Access to the shoreline is available from State Highway No. 1, which extends parallel to the shoreline along the bluffs overlooking the ocean.

The segment from Point Sur Lighthouse Reservation to the Monterey-San Luis Obispo County line, is about 54 miles long. The shoreline includes a large sand dune tombolo formation at the lighthouse, high seacliffs, pocket beaches, and canyon formations. The backshore area is mountainous with maximum elevations ranging to 3,500 feet. Offshore rocks are numerous. The shoreline zone is a part of the California Sea Otter Game Refuge. State Highway No. 1 traverses the entire reach at distances of 100 feet to as much as 2 miles inshore. Most of the highway is located atop high eroded seacliffs, which afford spectacular scenic views from numerous sites along the highway route. Just north of Point Sur, the Little Sur River flows into the Pacific Ocean to form a scenic beach about 1 mile long and about 200 feet wide. The lower canyon and lagoon are covered with a forest of redwoods and mixed conifers, and provide picnicking and camping areas on both sides of State Highway No. 1. The Point Sur and Big Sur areas to the south provide about 5 miles of sandy beach just south of the Point Sur tombolo. Seacliffs in these areas provide scenic views of the sandy beaches below. Windblown sand dunes in the backshore areas merge into coastal terraces in the more southerly part of this reach. Large outcroppings of rock are numerous. The backshore area, in large part, is occupied by the Los Padres National Forest. The upland terrain is rugged, and elevations of 3,000 feet are not uncommon. Land use ranges from agricultural to recreational and reserve. Erosion is not critical in this reach. Downcoast from Point Cooper, which is about 6 miles south of Point Sur, about 40 miles of the westerly boundary of Los Padres National Forest lies within an average distance of 0.5 mile from the shoreline interface as far south as Ragged Point. The southerly half of the National Forest boundary generally coincides

with the shoreline interface. The terrain is extremely rugged and access to shoreline areas is generally limited to steep hiking trails. A private toll road provides the only access to a substantial sandy beach area located in the vicinity of Pfeiffer Point, and 1.5 miles south of Point Cooper. This beach is available for picnicking, sunbathing and other recreational uses. The shoreline continues rugged to Julia Pfeiffer Burns State Park, about 10 miles to the south, which occupies about 1,700 acres, and more than 2 miles of shoreline frontage. About 4 miles to the south, at the mouth of Hot Springs Canyon, is the privately-owned Slates Hot Springs resort. John Little State Park is immediately downcoast. Access to beaches in this area is extremely treacherous, and most of these beaches are unsafe for public use. The state park occupies about 21 acres and about 0.5 mile of ocean-view frontage. Between John Little State Park and Lime Kiln Creek, a distance of about 11 miles, the shoreline is made up of eroded seacliffs. Offshore rocks are numerous. At the mouth of Lime Kiln Creek, a small, but attractive, pebble beach, terminated at either end by rock outcrops, creates a highly scenic area. Rockland Landing, at the mouth of Lime Kiln Creek, previously was used for loading of lime from the upland mountains, but has been abandoned. The area is scenically significant and has high recreation potential. Erosion is critical at several points in this reach, and threatens State Highway No. 1. From the mouth of Lime Kiln Creek to the Monterey-San Luis Obispo County line, the shoreline is a continuation of the steep, eroded seacliffs overlooking the ocean and offshore rocks, and is interspersed with occasional pocket beaches that are virtually inaccessible. Land uses are agricultural, park, recreational and military. The Hunter Liggett Military Reservation occupies a large part of the area south of Lime Kiln Creek. Erosion is critical at several points and threatens damage to State Highway No. 1.

San Luis Obispo County

This county has about 93 miles of shoreline, about 25 percent of the total mainland shoreline in the subregion. From the Monterey County line south to San Simeon Point, a distance of 18.5 miles, the shoreline is marked by offshore rocks and is backed by cliffs. State Highway No. 1 closely borders the coast throughout this reach, except at Ragged Point, 3 miles south of the Monterey County line. The terrain is so steep and rugged that access to the shoreline is difficult. Ragged Point is an accessible promontory with a wide, sandy beach on each side. This accessible promontory and its beaches are a potential public recreation area. The upland area, from Monterey County to Cambria is all part of the privately-owned Piedras Blancas Ranch.

In the 10.5-mile reach from San Simeon Point to the picturesque community of Cambria, the shoreline is less rugged and more accessible. Four publicly-owned sandy beach areas together comprise San Simeon State Beach Park. Other small, sandy pocket beaches in this reach are privately owned, as is the entire upland area. The entire reach is scenic and has

high recreational potential. The San Simeon-Cambria area has particularly significant scenic and biological values.

From Cambria to below Point Estero, a distance of about 7 miles, the shoreline is steep, rugged and rocky. State Highway No. 1 trends away from the shoreline, and this reach is inaccessible except by jeep trail.

The reach from Estero Point to Morro Bay, a distance of 14 miles, is lower marine-terrace formation, fronted in the most part by rocky shoreline, although the downcoast 4 miles are mostly sandy beach. The beach communities of Cayucos and Atascadero are located in this reach, and many homes and cottages are close to the shoreline. The beaches fronting these communities are low and narrow. Although no severe erosion was noted in the last comprehensive survey of shoreline conditions (for the period 1964-1966), the structural damage potential is high because of the lack of sufficient protective beach. Cayucos, Morro Strand, and Atascadero State Beaches, and a county-owned beach, make up over 3 miles of publicly-owned sandy beach. These beaches are heavily used during the summer, and, because the backshore is narrow, are very crowded during peak-use periods.

The entrance to Morro Bay is marked by a large volcanic plug, Morro Rock. Morro Bay has about 2,000 acres of water area and about 575 acres of marshland. It is an important stopover for migratory waterfowl and supports a large number of resident species, including the blue heron, cranes, and other shore and wading birds. In addition to the bird life, this estuary contains a full range of marine life, including clams, oysters and fish. The State Department of Fish and Game has proposed Morro Bay as a marine reserve.

Morro Bay is separated from the ocean by a barrier sandspit that extends about 4.5 miles downcoast from the Morro Bay entrance channel. The sandspit is publicly owned; 3.5 miles of it are in Morro Bay State Park and the remaining mile is owned by the county of San Luis Obispo. Access to the sandspit is by foot or dunebuggy. The sandy beach is extremely flat and wide, and is backed by active dunes. The downcoast boundary of Morro Bay State Park is about 4 miles upcoast from Point Buchon. Point Buchon marks the southern end of the broad bight known as Estero Bay; Estero Point is at the bay's northern end. The shoreline of Estero Bay is a closed littoral compartment, or nearly so. The shoreline generally can be expected to remain stable as long as erosion of the mountainous areas draining into Estero Bay supplies enough sand to offset frontal losses into deep water directly offshore.

From Point Buchon to Point San Luis, a distance of 13.5 miles, the shoreline is again extremely rugged and rocky. About 2 miles of this reach are publicly owned and comprise presently undeveloped Montana de Oro State Park. Its rugged shoreline, many reefs, and offshore rocks provide spectacular

surf and sea scenery; and the offshore waters are rich in marine life. Access to the shoreline throughout this entire reach is extremely limited. A nuclear power-generating plant is under construction in Diablo Canyon, about 9 miles upcoast from Point San Luis. The privately-owned upland is devoted to livestock grazing.

Point San Luis marks the upcoast end of San Luis Obispo Bay. Port San Luis, in the lee of the point, provides fair-weather shelter for moored small craft, and also has a petroleum terminal located on a pier. From Point San Luis downcoast for almost 15 miles, the shoreline area is low-lying and accessible. This reach has four beach communities - Avila, Shell Beach, Pismo Beach, and Oceano Beach - and in many areas, homes have been constructed close to the shoreline. Erosion damage in these communities is potentially critical. There are two publicly-owned recreational beaches, Pismo and Avila.

Pismo State Beach has an ocean frontage of about 5.6 miles. This State Beach has camping and picnicking facilities, and a broad, sandy, flat beach excellent for swimming and clamming. The beach is at the northern edge of 10 miles of public tidelands, comprising a clam reserve. Avila Beach, state-owned and county-operated, is a narrow, sandy beach providing day-use facilities only. Public beach frontage at Avila is about 0.4 mile. Both beaches are accessible by way of State Highway No. 1.

The 6-mile reach from the downcoast boundary of Pismo Beach State Park to the San Luis Obispo-Santa Barbara County line comprises most of the Santa Maria Dunes. This magnificent dune field has been identified as high priority for acquisition as scenic shoreline. The State of California Department of Parks and Recreation considers the Santa Maria Dunes "the most urgently needed landscape preservation project in the State." The sandy beach is unusually wide and has a very gently sloping foreshore. The upland area of the dunes has numerous lakes, which further enhance its recreational potential. A large portion of the area is either leased or owned outright by oil companies; however, a relatively small portion is presently used for the actual drilling of oil.

Santa Barbara County

The most northerly 3 miles of Santa Barbara County are a continuation of the Santa Maria Dunes previously described. Mussel Point, a small, rocky headland, marks the southern edge of the dune field. From Mussel Point to Point Sal, a distance of about 2.5 miles, the shoreline is comprised of broad, sandy beach. Around Point Sal, the shoreline is rocky. Point Sal State Beach, which lies about 1 mile downcoast from Point Sal, comprises about 1 mile of protected sandy pocket beach with many rocky outcroppings. The north boundary of Vandenberg Air Force Base is coincident with the south boundary of Point Sal State Beach. This Air Force Base extends south for

22.5 miles to Point Pedernales, and its shoreline is closed to public use. Point Sal State Beach has also been closed to public use at the request of the Air Force, which is presently paying rent to the State in order to control the property. About two-thirds of the shoreline within Vandenberg Air Force Base is broad, very flat, sandy beach. The middle third, around Purisima Point, is rocky, with occasional pocket beaches, and is backed by low-lying marine terrace. The Vandenberg area possesses many fine seashore values, in the event it becomes surplus to military requirements.

From Point Pedernales to Point Conception, a distance of about 20 miles, the shoreline is rocky, interspersed with occasional pocket beaches. The shoreline is backed by steep, rocky cliffs 100 to 400 feet high. The coast railroad runs along these cliffs and through several tunnels. Some seawall has been constructed to protect the railroad from damage. The upland area is privately-owned and is used for livestock grazing.

The only accessible shoreline between Point Pedernales and Point Conception is at Jalama County Beach. This sandy pocket beach, with an ocean frontage of 0.3 mile, is located at the mouth of Jalama Creek, and is reached by a side road from State Highway No. 1. The beach is steep and dangerous for swimming, but provides other shoreline recreation.

Along the entire shoreline of the county north of Point Conception, erosion is considered non-critical, except where damage to the coastal roads or railroad could occur.

Point Conception marks an abrupt change in the trend of the Region's coastline from a north-south to an east-west direction. North of Point Conception, the shoreline is fully exposed to wave action; but below this point, the shoreline is protected from severe wave action by the Arguello-Conception headland and is also somewhat sheltered by the Channel Islands lying offshore.

The reach from Point Conception to Gaviota, a distance of 14 miles, is comprised of narrow, low, sandy beach, backed by vertical bluffs ranging from about 50 to 100 feet in height. The entire upland area is privately owned and is used for livestock grazing. The coast railroad line runs close to shore, and occasional protective work, consisting of dumped rock, has been required. The shoreline is inaccessible by road and is closed to public use. At the upcoast limit of this reach, at Cojo Anchorage, construction of a small craft harbor of refuge is under consideration by the State of California.

At Gaviota, U.S. Highway No. 101 rejoins the coast. Gaviota State Park, which has an ocean shoreline of 1.4 miles, is fronted by low, sandy beach about 100 feet wide. The interior of the State Park has camping facilities.

The reach from Gaviota to Coal Oil Point, a distance of about 20 miles, is fronted by very narrow, low, sandy beach, and is backed in the most part by low vertical bluffs. The shoreline is all privately owned, with the exception of two State beaches. Refugio State Beach has a shoreline frontage of about 1.8 miles, and includes a pocket beach about 100 feet wide; the balance of the beach is extremely narrow. El Capitan State Beach also has about 1.8 miles of ocean frontage. During the winter, the beach tends to have exposed cobbles, but it is sandy during the summer months. The privately-owned shoreline is owned in part by oil companies; numerous wells, storage tanks and related facilities have been built along the shoreline and some revetment and seawall has been constructed to protect these facilities. Some homes have also been built close to the beach. In areas where urban development has occurred, erosion damage could be critical, although the shoreline generally is eroding at a fairly nominal rate.

From Coal Oil Point to Point Castillo, just upcoast from Santa Barbara Harbor, is a distance of about 12 miles. About 5.5 miles of this reach are publicly owned; including 2.5 miles of shoreline within State educational institutions, about 1.0 mile of public State beach, 1.0 mile of county beach, and 1.0 mile of city beach. This shoreline is fronted in part by sandy beach; the publicly-owned sectors are mostly fronted by beach about 100 feet wide, whereas the privately-owned sectors generally have extremely narrow, sandy beaches. The privately-owned upland area is in residential development. Many homes are built near the edge of the terrace formations backing the beach. The shoreline is eroding at about 1/2 foot per year, and damage due to recession of the bluffs is potentially high.

Goleta Slough is located in this segment, about 8 miles upcoast from Point Castillo. The slough lies within the campus of the University of California at Santa Barbara. It has an area of about 175 acres, and has tidal interchange as long as the sandbar at its mouth remains open. Wildlife includes several species of marsh and shore birds, as well as small mammals, such as rabbits and weasels.

Point Castillo marks the upcoast end of Santa Barbara Harbor. This harbor was completed by the city of Santa Barbara in 1930. Construction of the harbor interfered with natural littoral transport, and by 1934, sand had migrated along the breakwater and deposited in the lee at its end, forming a sandspit that encroached on the harbor channel. The beaches downcoast from the harbor no longer received a natural supply of sand and were eroding seriously. Federal participation in the required maintenance was authorized to the extent of $30,000 a year in 1935; since that date local interests have been maintaining the harbor with a pipeline dredge, bearing all of the costs -- about $100,000 a year -- in excess of the authorized Federal participation. The sand is placed on a feeder beach downcoast from the harbor. This program of continuous maintenance dredging has been effective in restoring the beaches downcoast from the harbor to a condition approaching stability.

Almost 3 miles of shoreline downcoast from Point Castillo, including the perimeter of Santa Barbara Harbor and the waterfront area of the city of Santa Barbara are publicly owned and open to recreational use. From the downcoast limit of this public waterfront to Sand Point, 7.4 miles downcoast, the shoreline is privately owned, except for about 1 mile of city and county shoreline. The upland area has a number of beachfront homes; in some areas, in spite of the sand-bypassing at Santa Barbara, the beach is extremely narrow. Quite a few private protective seawalls of varying effectiveness have been constructed along this reach. The potential erosion damage from waves of unusual direction or force is critical.

In the 4-mile reach from Sand Point to the downcoast boundary of the county, at Rincon Point, the shoreline is comprised of narrow, sandy beach. Carpenteria State Beach, with a shoreline frontage of about 1 mile, and a county beach with a frontage of about one-third mile, are located in this reach. The balance of the shoreline is privately owned; some structures have been built close to the shoreline and are subject to erosion damage. Carpenteria State Beach is a wide, sandy beach that has maintained its stability over the past few years; however, the State of California Division of Beaches and Parks has placed material to build up the beach. The beach width varies several feet with seasonal changes.

The Islands

Three of the northern Channel Islands are within the Central Coastal subregion. These islands are San Miguel, Santa Rosa and Santa Cruz; all three are in Santa Barbara County. San Miguel Island is under the jurisdiction of the U.S. Navy; the other two islands are privately owned. All three have been proposed for future acquisition by the National Park Service for inclusion in a Channel Islands National Park. This park would also include the two islands, Anacapa and Santa Barbara, in the South Coastal subregion that comprise the existing Channel Islands National Monument.

San Miguel Island, the most westerly, comprises about 14,000 acres. Outstanding features of the island include unspoiled sandy beaches, scenic cliffs and sea caves. There are archaeological sites relating to Indian settlements, and the island is believed to be the burial place of Juan Rodriguez Cabrillo, the first European to sight the California coast. Biological resources include the largest known colony of sea elephants in California, and colonies of sea lions. Sea otters and fur seals visit the island occasionally. There are also great rookeries of sea birds. San Miguel is managed by the Navy Department and is not open to the public. The Department of the Interior does not propose to administer the island for park purposes until it becomes surplus to military needs. Meanwhile, the Department of Interior and the Navy Department are working on a cooperative agreement for the protection of the island's outstanding scientific values.

Santa Rosa Island, which lies east of San Miguel, comprises about 55,000 acres, is about 15 miles long, and has a maximum width of 10 miles. The shoreline of the island varies from steep rocky bluffs to low, white sand beaches. In general, the island is mountainous, with many gullies and ravines. Like San Miguel, the island is rich in archaeological and biological resources. The kelp beds surrounding the island provide a splendid habitat for food chains upon which the marine mammals feed. Numerous rookeries of marine waterfowl are found on the island. Santa Rosa is privately owned and is used for livestock grazing. The Department of Interior has proposed public acquisition of the island.

Santa Cruz Island, which lies east of Santa Rosa Island and west of Anacapa Island, comprises about 62,000 acres, is about 21 miles long, and averages 5 miles in width. The island is mountainous, with a long, central valley. Santa Cruz Island provides a varied topography, and is densely wooded in some parts. The shoreline is generally comprised of steep, nearly vertical cliffs. Many of these cliffs have extensive sea caves and spout holes. There are also some sandy and pebbly pocket beaches that provide protected water suitable for swimming and diving. The waters off of the island are extremely clear and have fine kelp gardens and many varieties of fish. Both terrestrial and marine biology are rich and varied. Santa Cruz Island is privately owned by two owners. The Stanton Ranch comprises about 56,000 acres and the Gherini Ranch comprises about 6,000 acres. Limited public access to the shoreline in the Stanton Ranch is allowed on a fee-permit basis. Both the Stanton and Gherini Ranches are used for grazing livestock. The Department of the Interior has proposed public acquisition of the island.

All three of the islands have bays and coves that provide semiprotected anchorages for small craft. However, the islands are subject to strong and rapidly changing winds and seas; and vessels are often forced to leave their moorings and run to the lee of the islands. The Navigation Appendix proposes that at least one all-weather harbor of refuge should be provided on each island.

LAND USE

Upland land use is varied in this subregion. The predominant use of the mainland shoreline zone is agricultural, which accounts for about 34 percent. Urban use comprises about 19 percent. Santa Barbara County is the most urban, with about 26 percent of its shoreline zone in urban uses; however, Santa Cruz County is almost as urban, with 24 percent of its shoreline zone in urban areas. Military uses occupy 11 percent of the subregion's shoreline zone; all military use is in Monterey and Santa Barbara Counties. Public reserves account for about 16 percent of the subregion's shoreline zone. Other uses, including harbors, comprise the remaining 20 percent. The urban areas, typically, are beach front communities, with

homes and cottages fronting the shoreline. Land uses, by categories, are summarized in the following tabulation and are shown on Map 3.

County	Land use, in shoreline miles						
	Urban	Agriculture	Military	Public reserve	Harbors	Other	Total
Santa Cruz	10.0	15.6	0	11.8	0.1	4.4	41.9
Monterey	10.0	4.6	19.8	25.1	0.8	51.0	111.3
San Luis Obispo	18.0	49.9	0	13.5	0	11.7	93.1
Santa Barbara	27.9	52.1	21.5	5.0	0.8	2.5	109.8
Total, mainland	65.9	122.2	41.3	55.4	1.7	69.6	356.1
Islands	0	153.0	35.0	0	0	0	188.0

OWNERSHIP

Ownership of the shoreline zone was classified as Federal, State, local and private. About 14 percent of the subregion's mainland shoreline zone is Federally owned; 16 percent is owned by the state; 4 percent is owned by local governmental bodies; and the remaining 66 percent is privately owned. The Federally-owned shoreline included military reservations and U.S. Coast Guard facilities. The shoreline owned by the State and local governments was largely recreational. Much of the private land was agricultural. Ownership is summarized in the following tabulation, and is shown on Map 3.

County	Land ownership, in shoreline miles					
	Public				Private	Total
	Federal	State	Local	Subtotal		
Santa Cruz	0.4	12.7	0.9	14.0	27.9	41.9
Monterey	26.7	17.4	4.1	48.2	63.1	111.3
San Luis Obispo	0.6	17.1	3.0	20.7	72.4	93.1
Santa Barbara	23.5	9.8	6.2	39.5	70.3	109.8
Total, mainland	51.2	57.0	14.2	122.4	233.7	356.1
Islands	35.0	0	0	35.0	153.0	188.0

RECREATIONAL SHORELINE

The publicly-owned beaches in the subregion are about evenly divided between swimming and non-swimming beaches; 70 percent of the swimming beaches are south of Point Conception in Santa Barbara County. Much of the public beach north of Point Conception is characterized as non-swimming beach because of exposure and low ocean water temperatures. The publicly-owned natural scenic shoreline is all in San Luis Obispo County, and comprises Morro Rock, Montana de Oro State Park, and parts of San Simeon State Beach and Morro Bay State Park. Recreational and scenic shoreline available in 1965 is summarized in the following tabulation, and is shown on Map 4.

County	Recreational and scenic shoreline, in miles		
	Swimming beach	Non-swimming beach	Scenic shoreline
Santa Cruz	2.2	7.1	0 1/
Monterey	0.9	5.0	0
San Luis Obispo	3.3	13.3	6
Santa Barbara	13.6	0.6	0
Total, mainland	20.0	26.0	6
Islands	0	0	0

1/ Existing "scenic" shoreline does not meet National Park Service criteria for natural scenic shoreline.

EROSION CHARACTERISTICS

Geologically speaking, essentially the entire shoreline is eroding to some degree. However, for the purpose of this report, erosion characteristics have been classified into three categories -- critical erosion, non-critical erosion, and non-eroding. These categories are defined in the Introduction. The erosion characteristics of the subregion's mainland shoreline were estimated from historic trends, and data from available reports and studies. The character of shoreline formations, wave energies, littoral transport conditions, and existing structures in the active erosive zone were considered. Over 87 percent of the shoreline is eroding; 25 percent of the shoreline is eroding at a critical rate. The 13 percent of the shoreline that is not eroding is comprised of river and channel mouths, resistant rock, or shoreline protected by structures. Erosion rates in the subregion range from zero for non-eroding shoreline to about 5 feet a year in the most critically eroding areas. Erosion characteristics along the mainland shoreline are summarized in the following tabulation, and are shown on Map 5.

	Erosion characteristics, in miles			
	Critical	Non-critical	Non-eroding	Total
Santa Cruz	8.5	26.6	6.8	41.9
Monterey	4.7	93.2	13.4	111.3
San Luis Obispo	22.5	56.3	14.3	93.1
Santa Barbara	54.0	44.3	11.5	109.8
Total	89.7	220.4	46.0	356.1

PROTECTIVE AND MITIGATIVE EFFORTS

General

The term "protection," as used in this report, refers to both structural and non-structural measures for the reduction of damages caused by shoreline erosion. Structural measures include such works as stabilization and beach fill, seawall and revetment, and periodic replenishment of existing beaches. Non-structural measures include zoning and regulating the use of the shoreline. The term "development" refers to the creation of new beaches and acquisition of scenic shoreline and beach for public recreational use.

Protective and mitigative efforts undertaken to date along the subregion's shoreline include, primarily, structural measures. This work has been done under authorized Federal projects, by non-Federal agencies, and by private-property owners. Accomplishments relating to these activities are discussed in the following paragraphs.

Federal Projects

The authority under which the Federal beach erosion control and shore protection work was performed are discussed in the Regional Summary. One Federal beach erosion control and shore protection project has been authorized in the Central Coastal subregion, and is under construction. This project, which is in Santa Cruz County, provides for Federal reimbursement of a portion of the cost of shore protection to be constructed by local interests in the vicinity of the city of Santa Cruz. The project provides for intermittent seawalls, a groin and beach replenishment. The overall project area extends from Natural Bridges Beach State Park to the vicinity of Capitola. About 1 mile of seawall has been constructed within the project reach; about 80 percent of the total seawall authorized. No work has been initiated on construction of the groin or beach replenishment. A small beach-erosion project is under investigation at Capitola, but has not been authorized.

The other Federal work undertaken in the subregion is mitigative. Santa Barbara Harbor, which was constructed by local interests, intercepted the natural downcoast movement of littoral material, and caused starvation of the downcoast beaches. An authorized Federal harbor maintenance project permits Federal contribution toward the cost of harbor maintenance dredging; the dredged material is deposited on the downcoast beaches to mitigate the effects of continuous erosion that threatens highly valuable shoreline property.

On 27 July 1946, the State Division of Beaches and Parks made formal application for a continuing cooperative Federal-State study of the entire Pacific Coast shoreline of the State of California. Many sites in the subregion have been surveyed under this program. Additional studies are continuing informally, involving collection of data at state beaches along the entire shoreline of the subregion.

Non-Federal and Private Work

Local agencies and private property owners have constructed seawalls and have placed rock and concrete rubble to protect seriously eroding areas in Santa Cruz County. Some of this work has been constructed in accordance with Corps of Engineers design; some is improvised. The State Division of Highways has performed considerable maintenance and repair work on State Highway No. 1 where it lies close to shore. Some of this work has been required as a result of shoreline erosion. In the southern part of Santa Barbara County, downcoast from Santa Barbara Harbor, local agencies and

private property owners have constructed groins, seawalls and revetments at critically eroding areas throughout the entire reach. The State of California has also placed material to widen Carpenteria Beach, which is in this reach.

Non-structural Measures

The four counties in the subregion have all adopted general master plans or shoreline development plans. These counties are all recreationally oriented, and that sector of the economy is quite significant. The county plans propose acquisition of nearly all shoreline for recreational purposes. Implementation of these plans, however, may be difficult.

SHORELINE EROSION DAMAGE, PRESENT CONDITIONS

Estimates of shoreline erosion damages, under present conditions, were based on land use, rate of erosion and market value of shoreline property that is subject to erosion damage. A detailed explanation of the method used for evaluating erosion damage is given in the Regional Summary.

The estimated average annual shoreline erosion damages, under present conditions, are shown in the following tabulation.

	Average annual shoreline erosion damage, in $1,000
Santa Cruz	$ 700
Monterey	530
San Luis Obispo	280
Santa Barbara	700
Total	$2,210

Future Needs in the Shoreline Zone

GENERAL

Future needs are evaluated in terms of reducing shoreline erosion damages and meeting the needs for recreational shoreline, including conservation of scenic shoreline. A detailed explanation of the method used to evaluate erosion damages, and the means whereby these damages could be reduced is

contained in the Regional Summary. The Regional Summary also contains a detailed explanation of the methods used to evaluate the needs for recreational shoreline.

SHORELINE EROSION DAMAGES, FUTURE CONDITIONS

The dollar value of future erosion damages were estimated by applying economic growth factors based upon population projections and related economic indices to data for the base year (1965). It was assumed that, on the average, erosion rates would remain constant and that no erosion control projects would be constructed during the study period. The projected average annual shoreline erosion damage for the Central Coastal subregion under present and future conditions are shown in the following tabulation.

County	Average annual shoreline erosion damages, in $1,000			
	1965	1980	2000	2020
Santa Cruz	700	1,300	3,300	7,100
Monterey	530	830	1,840	3,940
San Luis Obispo	280	330	550	910
Santa Barbara	700	1,030	1,590	2,220
SUBREGION TOTAL	2,210	3,490	7,280	14,170

SHORELINE RECREATION NEEDS

Projected needs for recreational beaches are based on projections of population and related factors for the Central Coastal subregion and adjacent inland subregions. Projected needs for conservation of scenic shoreline are based upon the availability of the resource and recommendations of the National Park Service, the State of California and other governmental entities. The projected requirements for public recreational shoreline in the Central Coastal subregion are shown in the following tabulation.

County	Cumulative Public Recreational Shoreline Needs, in Miles			
	1965	1980	2000	2020
Santa Cruz				
Swimming beach	1.3	1.4	2.5	4.4
Non-swimming beach	0.4	0.6	1.0	2.0
Scenic shoreline 1/	0	0	0	0
Monterey				
Swimming beach	1.0	1.2	2.0	3.0
Non-swimming beach	2.2	3.1	5.6	11.0
Scenic shoreline	0	6.0	7.0	7.0
San Luis Obispo				
Swimming	0.2	0.2	0.3	0.6
Non-swimming	1.2	1.8	2.7	6.0
Scenic shoreline	6.0	23.0	38.0	38.0
Santa Barbara				
Swimming	3.5	4.4	8.2	15.0
Non-swimming	0.2	0.3	0.7	1.0
Scenic shoreline	0	153.0	188.0	188.0
SUBREGION TOTAL				
Swimming	6.0	7.2	13.0	23.0
Non-swimming	4.0	5.8	10.0	20.0
Scenic shoreline	6.0	182.0	233.0	233.0

1/ Existing "scenic" shoreline does not meet National Park Service criteria for natural scenic shoreline.

Means to Satisfy Future Needs in the Shoreline Zone

GENERAL

The shoreline program for the Central Coastal subregion includes structural and non-structural protective measures to reduce potential future erosion damages, and the acquisition of scenic shoreline for public recreational use.

STRUCTURAL MEASURES

In the development of the structural phase of the shoreline program, emphasis was placed on those urban areas that are being threatened with critical erosion. Included in the nearly 16 miles of critical erosion in the subregion are numerous reaches of highway and railroad rights-of-way located on high bluffs. In many of these reaches, relocation of the highways in lieu of construction of shoreline protective works is considered to be the better alternative; however, with regard to the railroad, relocation is generally economically infeasible and protective works are required. Non-structural protection of eroding areas by means of shoreline management is discussed in subsequent paragraphs.

In addition to affording protection against erosion, some of the structural measures, namely stabilization works and beach replenishment, provide incidental beach areas for public recreation. These beach areas, together with available existing beaches, are adequate to meet the projected public beach requirements within the study period.

Table CC-1, at the end of this chapter, shows the projected scope, in miles, of potential shoreline protection projects for the subregion by time frames.

NON-STRUCTURAL MEASURES

As shown in Table CC-1, the shoreline structural protection program for the subregion is minimal throughout the study period. Due to the unique scenic beauty and the wilderness character of much of the subregion's shoreline, it has been considered that emphasis should be placed on non-structural reduction of potential future erosion damages. A suitable non-structural measure would be the zoning and regulation of shoreline uses to restrict urban encroachment into the shoreline erosive zone.

Several bills have been presented to the State Legislature that would establish State and regional commissions to deal with the problems associated with the conservation and development of the California coastal zone. These bills propose that the commissions would prepare and adopt comprehensive and long-range coastal zoning plans and criteria and standards for numerous environmental factors that could, if uncontrolled, detrimentally change or irreversibly modify the shoreline environment. Regulating land use to prevent structural encroachment into the erosive zone would come within these criteria and standards. Such regional plan, by necessity, however, would be broad in scope and general in concept and probably would not contain a detailed inventory of the erosion characteristics of the shoreline. Accordingly, the shoreline program presented herein includes a provision for a detailed study of the shoreline with respect to its erosive character so that definitive guidelines may be established for the non-structural reduction of potential future erosion damages.

At the Federal level, several bills have been introduced in Congress that would establish a policy of Federal participation with regard to the conservation and development of the Nation's coastal resources.

ACQUISITION OF RECREATIONAL SHORELINE

The Central Coastal subregion contains 6 miles of the 76 miles of existing (1965) scenic mainland coastal shoreline in the California Region that are available for public recreational use. Additional acquisitions of 176 miles (23 miles of mainland and 153 miles of Channel Islands shoreline) in the 1966-1980 time frame, 51 miles (16 miles of mainland and 35 miles Channel Islands shoreline) in the 1981-2000 time frame. It is proposed that all acquisition be completed by 2000. By 2000, if the acquisition program is implemented, the subregion will have under public ownership about 233 miles of scenic shoreline, or about 45 miles of the 218-mile regional total of mainland scenic shoreline plus 188 miles of the Channel Islands shoreline, which would comprise all of the acquisition of insular scenic shoreline for the California Region.

Publicly-owned beaches in the Central Coastal subregion presently exceed the 43 miles of projected beach requirements in 2020 for the subregion, although some of the beaches are not located near population centers and others are not readily accessible. It is expected, however, that recreational beach requirements for the subregion would be met during the study period by expansion or creation of sandy beach areas at existing sites in connection with shore protection projects and by improvement of access to existing beaches.

EFFECTIVENESS OF THE SHORELINE PROGRAM

As indicated in the tabulation on page CC-20, the average annual erosion damages for the Central Coastal subregion will increase from about $2.2 million in 1965 to $3.5 million by 1980, $7.3 million by 2000, and $14.2 million by 2020, if no measures to prevent these damages are implemented after 1965. If the shoreline program presented herein is fully implemented, the average annual residual shoreline erosion damages will decrease from about $2.2 million in 1965 to about $1.6 million by 1980, $1.2 million by 2000, and $1.2 million by 2020, as shown in Table CC-2. The overall reduction of the potential average annual shoreline erosion damages due to full implementation of the shoreline program amounts to about $1.9 million by 1980, $5.1 million by 2000, and $13.0 million by 2020. Table CC-2 summarizes the effectiveness of the shoreline protection program in reducing shoreline erosion damage in the subregion.

Publicly-owned recreational shoreline in the Central Coastal subregion will increase from about 52 shoreline miles to 285 shoreline miles to meet swimming and non-swimming beach and scenic shoreline demands during the study period. Swimming beach frontage will increase from about 20 miles to 26 miles, non-swimming beach frontage will remain at about 26 miles, and scenic shoreline frontage will increase from 6 miles to 233 miles during the study period. The 233 miles of scenic shoreline will include the offshore scenic shoreline reaches of the Channel Islands and thereby conserve 188 miles of significant insular scenic shoreline in the subregion and the California Region. Table CC-3 summarizes the extent of shoreline available by types of shoreline and by time frames, if the program is implemented.

Implementation

BASES FOR COST ESTIMATES

Estimates of costs for the shoreline protection program in the Central Coastal subregion were based to a large extent on data from available reports and current studies, adjusted to reflect particular site conditions. Reconnaissance-scope estimates were made where existing data were not available. In general, unit costs were developed for each subregion for structural measures and applied to sites with similar characteristics. Costs for scenic shoreline were based on prevailing land values for the particular area. The extent of each scenic shoreline site was determined by its scenic value and topography. Costs associated with non-structural measures to reduce potential future shoreline erosion damages were based on the estimated cost of studies needed to establish necessary guidelines for regulation of land use within the shoreline erosive zone.

ESTIMATED SHORELINE PROGRAM COSTS

The estimated installation costs for the shoreline protection program in the Central Coastal subregion amount to about $22.1 million for the 1966-1980 time frame, $18.3 million for the 1981-2000 time frame, and $15.2 million for the 2000-2020 time frame. These costs do not include expenditures for access roads, or parking and sanitary facilities, which are included in Appendix XII: Recreation, under the general categories of development and acquisition costs for recreation land Classes I and II. Cumulative annual maintenance costs amount to about $350,000, $590,000 and $800,000 for the respective time frames. All maintenance costs are the responsibility of non-Federal interests, with the exception of those connected with scenic shoreline within the Los Padres National Forest and future national parks proposed for the subregion shoreline. Table CC-4 summarizes the shoreline protection program costs for the Central Coastal subregion.

TABLE CC-1
CENTRAL COASTAL SUBREGION
Potential Projects, in Miles

Item	1966-1980	1981-2000	2001-2020	Program Total
Santa Cruz County				
Beach Stabilization	1.0	1.0	0	2.0
Seawalls	2.0	2.0	1.0	5.0
Beach Replenishment	1.0	1.0	2.0	4.0
Beach Development	0	0	0	0
Monterey County				
Beach Stabilization	0	1.0	1.0	2.0
Seawalls	1.0	1.0	1.0	3.0
Beach Replenishment	0	1.0	1.0	2.0
Beach Development	0	0	0	0
San Luis Obispo County				
Beach Stabilization	0	2.0	0	2.0
Seawalls	0	0	0	0
Beach Replenishment	1.5	2.5	0	4.0
Beach Development	0	0	0	0
Santa Barbara County				
Beach Stabilization	5.0	2.0	0	7.0
Seawalls	0	0.6	0	0.6
Beach Replenishment	0	0	0	0
Beach Development	0	0	0	0
SUBREGION TOTAL				
Beach Stabilization	6.0	6.0	1.0	13.0
Seawalls	3.0	3.6	2.0	8.6
Beach Replenishment	2.5	4.5	3.0	10.0
Beach Development	0	0	0	0

TABLE CC-2
CENTRAL COASTAL SUBREGION
Estimated Average Annual Shoreline Erosion Damages and Damage Reduction through Shoreline Program, in $1,000 (1965 prices)

Item	Santa Cruz County	Monterey County	San Luis Obispo County	Santa Barbara County	Subregion
Average annual damages, 1965	700	530	280	700	2,210
Average annual damage by 1980 with no shoreline program	1,300	830	330	1,030	3,490
Reduction in damage with 1966 to 1980 shoreline program					
Structural measures	560	130	70	550	1,310
Non-structural measures	210	200	60	140	610
Program total	770	330	130	690	1,920
Residual annual damage in 1980	530	500	200	340	1,570
Average annual damage by 2000 with no shoreline program after 1980	1,110	1,030	300	520	2,960
Reduction in damage with 1981 to 2000 shoreline program					
Structural measures	620	430	180	60	1,290
Non-structural measures	70	150	40	170	430
Program total	690	580	220	230	1,720
Residual annual damage in 2000	420	450	80	290	1,240
Average annual damage by 2020 with no shoreline program after 2000	700	770	130	410	2,010
Reduction in damage with 2001 to 2020 shoreline program					
Structural measures	230	350	0	0	580
Non-structural measures	40	60	30	130	260
Program total	270	410	30	130	840
Residual annual damage in 2020	430	360	100	280	1,170
Estimated annual damage in 2020 with no shoreline program after 1965	7,100	3,940	910	2,220	14,170
Total reduction in annual damage due to 1966 to 2020 shoreline program	6,670	3,580	810	1,940	13,000

TABLE CC-3

CENTRAL COASTAL SUBREGION

Estimated Recreational Shoreline Needed, and Recreational Shoreline Made Available by the Program, in Miles

Item	Santa Cruz County			Monterey County			San Luis Obispo County			Santa Barbara County			Total subregion		
	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline
Available in 1965	2.0	7.0	0	1.0	5.0	0	3.3	13.3	6.0	13.6	0.6	0	19.9	25.9	6.0
Needed by 1980	1.4	0.6	-	1.2	3.1	-	0.2	1.8	-	4.4	0.3	-	7.2	5.8	-
Deficiency (-) or surplus (+)	+0.6	+6.4	-	-0.2	+1.9	-	+3.1	+11.5	-	+9.2	+0.3	-	+12.7	+20.1	-
1966-1980 program supply	1.0	0	0	0.2	0	6.0	0	0	17.0	0	0	153.0*	1.2	0	176.0
Available in 1980 with program	3.0	7.0	0	1.2	5.0	6.0	3.3	13.3	23.0	13.6	0.6	153.0*	21.1	25.9	182.0
Needed by 2000	2.5	1.0	-	2.0	5.6	-	0.3	2.7	-	8.2	0.7	-	13.0	10.0	-
Deficiency (-) or surplus (+)	+0.5	+6.0	-	-0.8	-0.6	-	+3.0	[illegible]	--	+5.4	-0.1	-	+8.1	+15.9	-
1981-2000 program supply	1.0	0	0	0.8	0	1.0	0	[illegible]	15.0	0	0.1	35.0*	1.8	0.1	51.0
Available in 2000 with program	4.0	7.0	0	2.0	5.0	7.0	3.3	13.3	38.0	13.6	0.7	188.0*	22.9	26.0	233.0
Needed by 2020	4.4	2.0	-	3.0	11.0	-	0.6	6.0	-	15.0	1.0	-	23.0	20.0	-
Deficiency (-) or surplus (+)	-0.4	+5.0	-	-1.0	-6.0	-	+2.7	+7.3	-	-1.4	-0.3	-	-0.1	+6.0	-
2001-2020 program supply	0.4	0	0	1.0	0	0	0	0	0	1.4	0.3	0	2.8	0.3	0
Available in 2020 with program	4.4	7.0	0	3.0	5.0	7.0	3.3	13.3	38.0	15.0	1.0	188.0*	25.7	26.3	233.0
Needed by 2020	4.4	2.0	-	3.0	11.0	-	0.6	6.0	-	15.0	1.0	-	23.0	20.0	
Deficiency (-) or surplus (+) at end of program	0	+5.0	-	0	-6.0	-	+2.7	+7.3	-	0	0	-	+2.7	+6.3	-

*Scenic shoreline on Channel Islands.

TABLE CC-4

CENTRAL COASTAL SUBREGION

Estimated Shoreline Program Costs, in $1,000 (1965 prices)

1966-1980 PROGRAM

Item	Santa Cruz County	Monterey County	San Luis Obispo County	Santa Barbara County	Subregion Total
STRUCTURAL MEASURES:					
Installation costs					
Federal	3,200	500	600	2,000	6,300
Non-Federal	3,200	500	600	2,000	6,300
Subtotal	6,400	1,000	1,200	4,000	12,600
Annual OM & R					
Federal	0	0	0	0	0
Non-Federal	110	10	60	40	220
Subtotal	110	10	60	40	220
NON-STRUCTURAL MEASURES:					
Installation costs					
Federal	0	0	0	7,300	7,300
Non-Federal	40	1,920	90	110	2,160
Subtotal	40	1,920	90	7,410	9,460
Annual OM & R					
Federal	0	0	0	0	0
Non-Federal	0	20	0	0	20
Subtotal	0	20	0	0	20
1966-1980 PROGRAM					
Federal	3,200	500	600	9,300	13,600
Non-Federal	3,240	2,420	690	2,110	8,460
Total	6,440	2,920	1,290	11,410	22,060
Annual OM & R	110	30	60	40	240

Continued

TABLE CC-4--Continued

CENTRAL COASTAL SUBREGION

Estimated Shoreline Program Costs, in $1,000 (1965 prices)

1981-2000 PROGRAM

Item	Santa Cruz County	Monterey County	San Luis Obispo County	Santa Barbara County	Subregion Total
STRUCTURAL MEASURES:					
Installation costs					
Federal	3,200	2,700	1,800	980	8,680
Non-Federal	3,200	2,700	1,800	980	8,680
Subtotal	6,400	5,400	3,600	1,960	17,360
Annual OM & R					
Federal	0	0	0	0	0
Non-Federal	108	99	116	20	343
Subtotal	108	99	116	20	343
NON-STRUCTURAL MEASURES:					
Installation costs					
Federal	0	0	0	0	0
Non-Federal	40	420	90	410	960
Subtotal	40	420	90	410	960
Annual OM & R					
Federal	0	0	0	0	0
Non-Federal	0	3	0	0	3
Subtotal	0	3	0	0	3
1981-2000 PROGRAM					
Federal	3,200	2,700	1,800	980	8,680
Non-Federal	3,240	3,120	1,890	1,390	9,640
Total	6,440	5,820	3,690	2,370	18,320
Annual OM & R	108	102	116	20	346

Continued

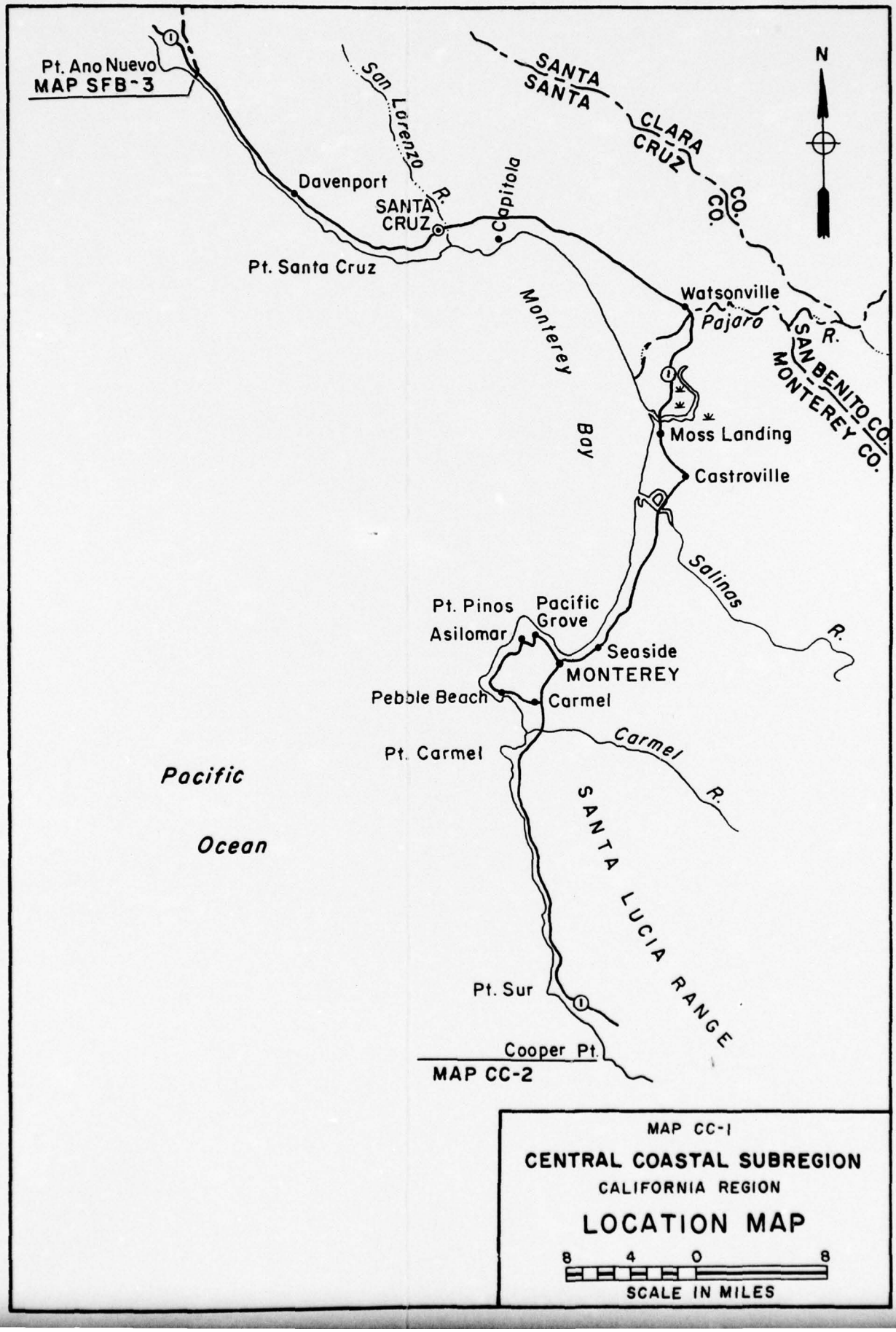
TABLE CC-4--Continued

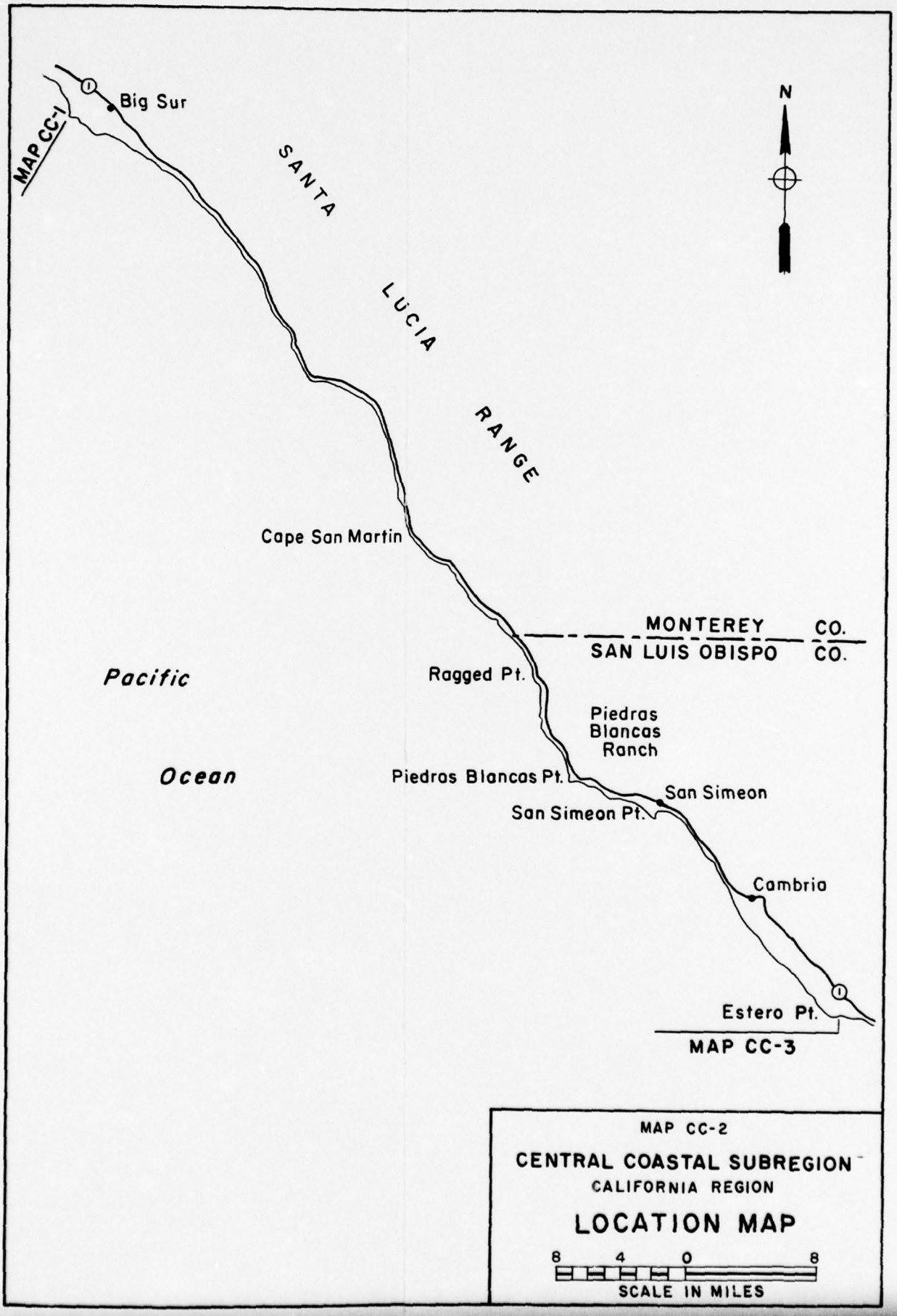
CENTRAL COASTAL SUBREGION

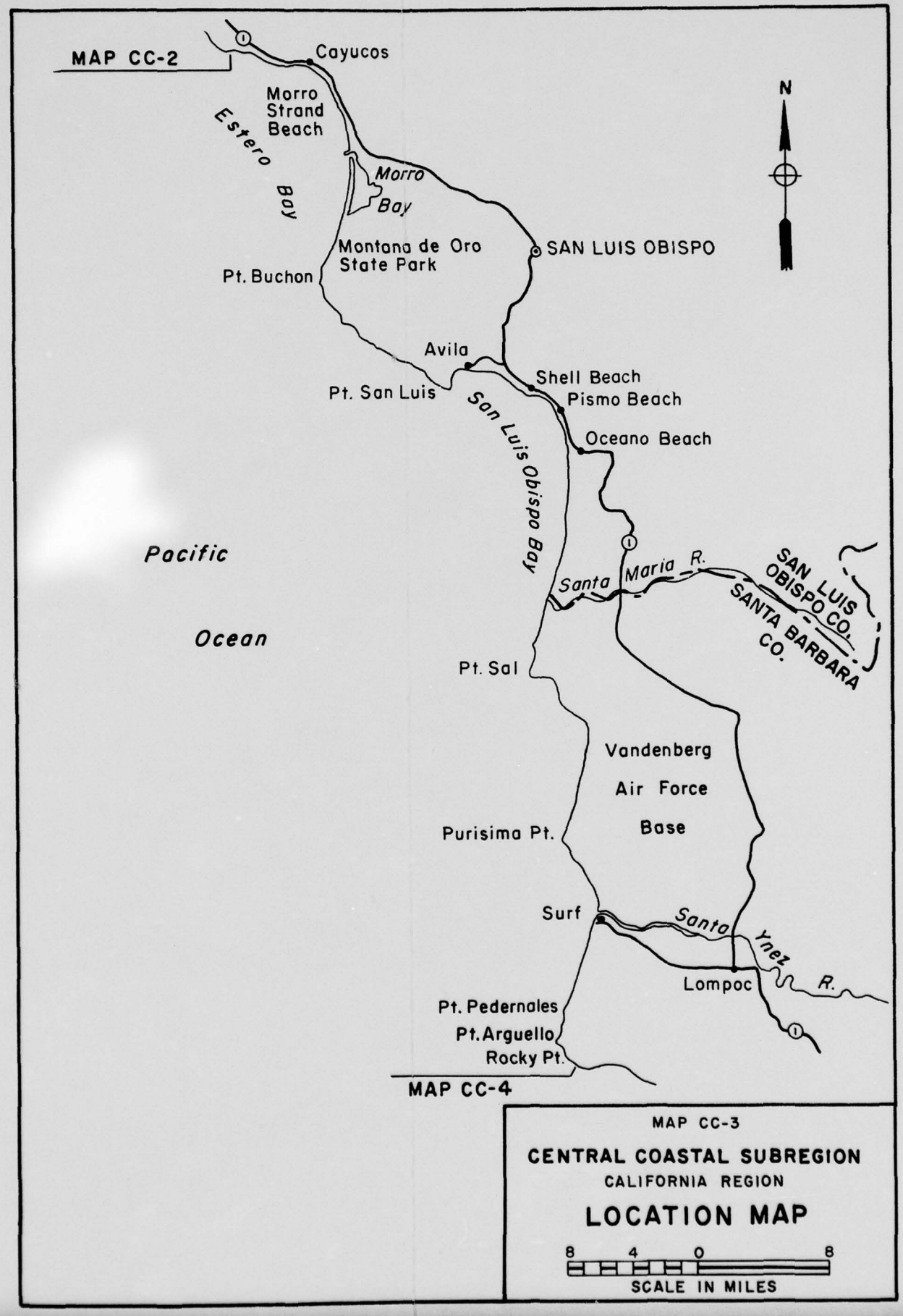
Estimated Shoreline Program Costs, in $1,000 (1965 prices)

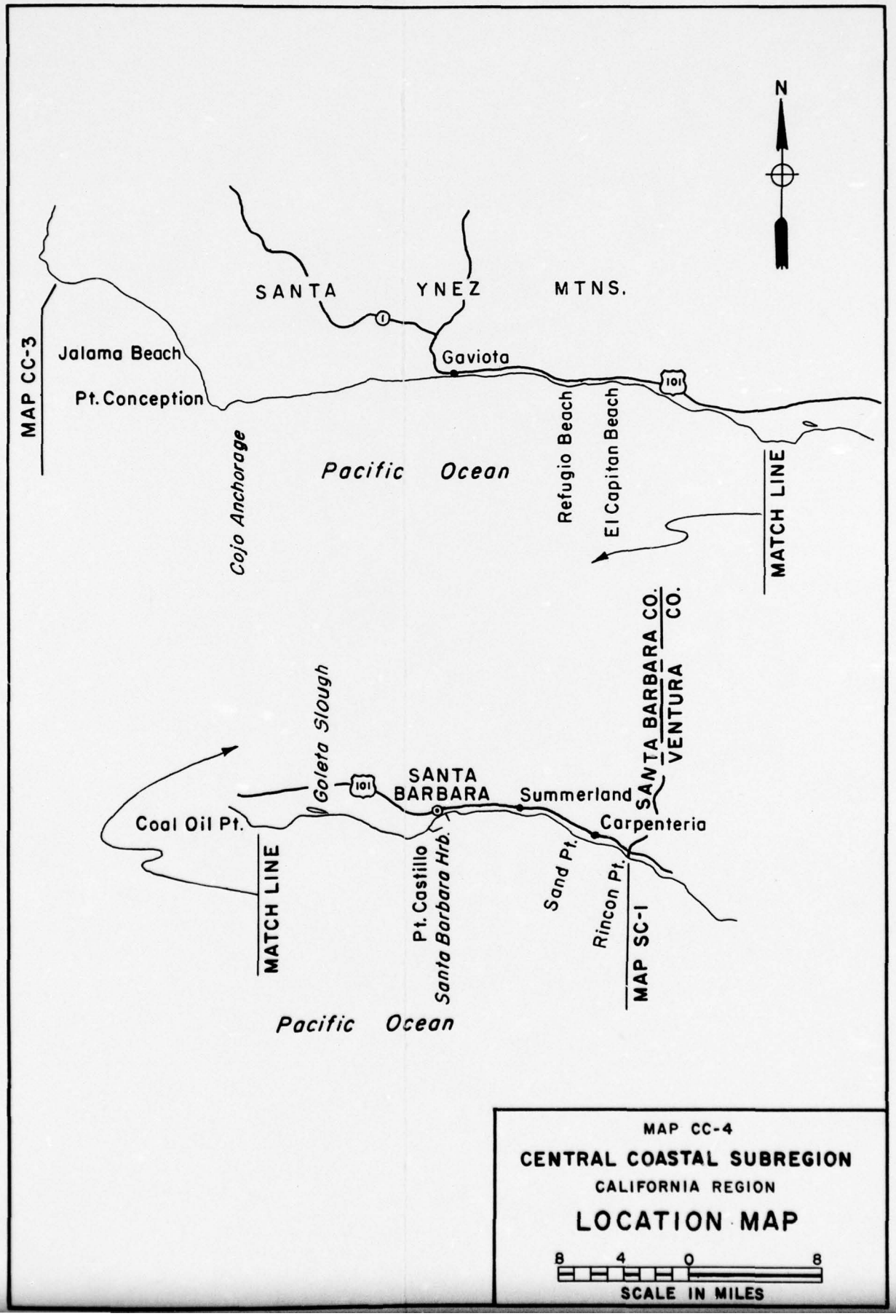
2001-2020 PROGRAM

Item	Santa Cruz County	Monterey County	San Luis Obispo County	Santa Barbara County	Subregion Total
STRUCTURAL MEASURES:					
Installation costs					
Federal	1,300	2,700	0	0	4,000
Non-Federal	1,300	2,700	0	0	4,000
Subtotal	2,600	5,400	0	0	8,000
Annual OM & R					
Federal	0	0	0	0	0
Non-Federal	90	120	0	0	210
Subtotal	90	120	0	0	210
NON-STRUCTURAL MEASURES:					
Installation costs					
Federal	0	0	0	0	0
Non-Federal	40	120	90	6,910	7,160
Subtotal	40	120	90	6,910	7,160
Annual OM & R					
Federal	0	0	0	0	0
Non-Federal	0	0	0	0	0
Subtotal	0	0	0	0	0
2001-2020 PROGRAM					
Federal	1,300	2,700	0	0	4,000
Non-Federal	1,340	2,820	90	6,910	11,160
Total	2,640	5,520	90	6,910	15,160
Annual OM & R	90	120	0	0	210


Pt. Ano Nuevo
MAP SFB-3
San Lorenzo R.
SANTA CLARA CO.
SANTA CRUZ CO.
N
Davenport
SANTA CRUZ
Capitola
Pt. Santa Cruz
Watsonville
Pajaro R.
SAN BENITO CO.
MONTEREY CO.
Monterey Bay
Moss Landing
Castroville
Salinas R.
Pt. Pinos
Pacific Grove
Asilomar
Seaside
MONTEREY
Pebble Beach
Carmel
Carmel R.
Pt. Carmel
Pacific Ocean
SANTA LUCIA RANGE
Pt. Sur
Cooper Pt.
MAP CC-2
MAP CC-1
CENTRAL COASTAL SUBREGION
CALIFORNIA REGION
LOCATION MAP
8 4 0 8
SCALE IN MILES


MAP CC-1
Big Sur
SANTA
LUCIA
RANGE
N
Cape San Martin
MONTEREY CO.
SAN LUIS OBISPO CO.
Pacific
Ocean
Ragged Pt.
Piedras
Blancas
Ranch
Piedras Blancas Pt.
San Simeon
San Simeon Pt.
Cambria
Estero Pt.
MAP CC-3
MAP CC-2
CENTRAL COASTAL SUBREGION
CALIFORNIA REGION
LOCATION MAP
8 4 0 8
SCALE IN MILES


MAP CC-2
Cayucos
Morro Strand Beach
Estero Bay
Morro Bay
Montana de Oro State Park
Pt. Buchon
SAN LUIS OBISPO
N
Avila
Pt. San Luis
Shell Beach
Pismo Beach
Oceano Beach
San Luis Obispo Bay
Pacific Ocean
Santa Maria R.
SAN LUIS OBISPO CO.
SANTA BARBARA CO.
Pt. Sal
Vandenberg Air Force Base
Purisima Pt.
Surf
Santa Ynez R.
Lompoc
Pt. Pedernales
Pt. Arguello
Rocky Pt.
MAP CC-4
MAP CC-3
CENTRAL COASTAL SUBREGION
CALIFORNIA REGION
LOCATION MAP
8 4 0 8
SCALE IN MILES



MAP CC-4

CENTRAL COASTAL SUBREGION

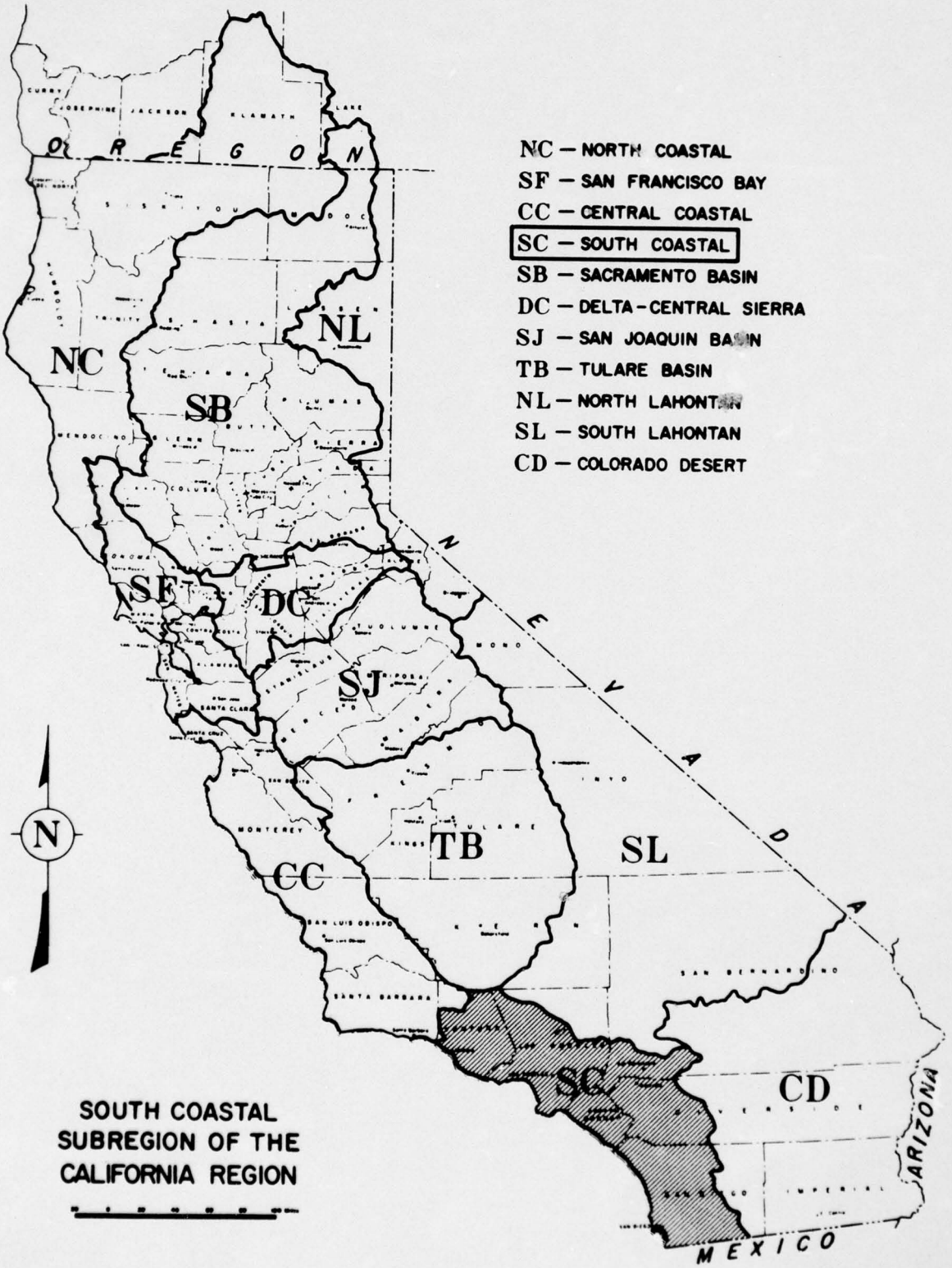
CALIFORNIA REGION

LOCATION MAP

8 4 0 8

SCALE IN MILES

SOUTH COASTAL SUBREGION


NC — NORTH COASTAL
SF — SAN FRANCISCO BAY
CC — CENTRAL COASTAL
SC — SOUTH COASTAL
SB — SACRAMENTO BASIN
DC — DELTA-CENTRAL SIERRA
SJ — SAN JOAQUIN BASIN
TB — TULARE BASIN
NL — NORTH LAHONTAN
SL — SOUTH LAHONTAN
CD — COLORADO DESERT
OREGON
NEVADA
ARIZONA
MEXICO
N
SOUTH COASTAL
SUBREGION OF THE
CALIFORNIA REGION

SOUTH COASTAL SUBREGION

Description of the Subregion

PHYSICAL CHARACTERISTICS

The South Coastal subregion of the California Region includes the shoreline of Ventura, Los Angeles, Orange, and San Diego counties; and the offshore islands of Anacapa, Santa Barbara, San Nicolas, Santa Catalina, and San Clemente. The total mainland shoreline length is approximately 233 miles, not including the shoreline of bays and estuaries. The total shoreline length of the islands is 209 miles. The configuration of the mainland subregion is shown on the opposite index map.

The subregion is characterized by three basic shoreline types; gradually sloping flood plains that merge easily with the ocean, uplifted marine terraces that usually have near-vertical faces along the shore, and the steep, rugged mountains that border much of the California Region's coast. The offshore islands generally have steep, rocky shores interspersed with a few small pocket beaches. The exception is San Nicolas which is fairly low-lying with considerable sandy beach.

The submarine topography resembles that of the coast and is composed of deep basins separated by steep mountain ranges; the tops of these ranges form the aforementioned islands. The 600-foot contour of the continental shelf varies from 1 to 10 miles offshore. Five major submarine canyons trench the shelf along this subregion.

CLIMATE AND EXPOSURE

The South Coastal subregion has a temperate mediterranean-type climate. This climate type is characterized by warm, dry summers and mild winters, with moderate temperatures exhibiting neither pronounced diurnal nor seasonal variation. Temperatures below freezing are extremely rare, except at high elevations. The average recorded temperatures in the Los Angeles area, range from a mean daily maximum of about 78° F during the warmest month to a mean daily minimum of about 50° F during the coolest month, with recorded extremes of 106° and 36°. The ocean waters of the subregion are warm enough for water-contact sports through much of the year. The water temperature of the ocean is in the high 50's during the winter and reaches a summer high of about 70°, with a summer mean of about 68°.

At lower elevations, rainfall occurs almost exclusively during the winter months. Average annual rainfall in coastal areas of the subregion ranges from about 10 to 20 inches. Measurable amounts of

rainfall occur on an average of about 40 days a year. Severe winds are relatively infrequent; the typical regime consists of a diurnal system of offshore and onshore breezes with a mean speed of about 5.7 knots. Strong offshore winds through the passes and valleys may develop, usually in the late fall and winter, due to atmospheric pressure differences. These winds are often amplified by the mechanical effects of topography, particularly in the coastal strip immediately adjacent to mountain ranges, and may reach velocities exceeding 50 knots. Coastal fog may occur at any time of the year, usually at night and in the early morning. The maximum duration of fog occurs October through December, and the minimum occurs in May.

Ocean waves off the coast of the South Coastal subregion can be classified as northern hemisphere swell, southern hemisphere swell, and sea. Swell and sea are terms given to waves generated by distant and local winds, respectively. Northern hemisphere swell is felt along the coast over one-half of the year, predominantly through the winter months. This results mainly from high latitude storms. This swell approches from a westerly direction and constitutes the main source of wave energy. Northern hemisphere swell may also occur as a result of tropical hurricane-type storms, called "chubascos," which may develop off the coast of Mexico from July through October. Southern hemisphere swell is generated by winds associated with storms in the austral winter in the South Pacific; these storms are of even greater size and intensity than those causing the northern hemisphere swell. Southern hemisphere swell is most common during August and September, but occurs significantly from May through October. This swell approaches from a south through westerly direction. Due to the orientation of the coastline and the offshore islands, this is the most critical wave condition for the subregion. Seas are generated either by local storms with strong pressure gradients, or by the diurnal sea breeze. Seas generally approach the coast from a western direction. The Channel and Offshore Islands normally provide considerable sheltering to the mainland coast from both swell and sea.

POPULATION DISTRIBUTION

The South Coastal subregion had a population of about 9,910,000 in 1965, which was approximately 55 percent of the total population of the California Region, estimated at 18,106,000. The largest population center was greater Los Angeles with a population of about 7,500,000.

The subregion population has been projected (California Base Plan) at 13,895,000 by 1980; 19,200,000 by 2000; and 23,771,000 by 2020. The 2020 subregional population represents about 43 percent of the projected regional population of 54,941,000 for that year.

Development in the subregion has virtually filled coastal Los Angeles County, much of the northern two-thirds of Orange County, and is currently causing rapid growth in Ventura County. A rapid increase in the population of coastal San Diego County is expected about 1990, with most of the developable acreage in the subregion in use by 2020.

ECONOMY

The highly urban South Coastal subregion employs almost 56 percent of the region's total civilian work force. The economy of the subregion is closely related to commercial-industrial activities, with considerable emphasis on aerospace industries. Agriculture and the chemical and petroleum industries also contribute significantly to the economy. In 1965, the manufacturing and trade sectors accounted for 30 and 20 percent, respectively, of the total civilian employment in the subregion; government employment was 15 percent; agriculture, forestry and fishing together accounted for 2 percent; and all other sectors accounted for 33 percent. Dispersion of urban population is encroaching on agricultural lands, causing agriculture to become less important as an economic sector. The "all other" sector is expected to gain in relative importance. A component of this sector relates to tourism, which is based on the subregion's climate, beaches, and notable attractions such as Disneyland and the entertainment industry. Also included in this sector are the important construction, personal services, and business service economic sections.

TRANSPORTATION

The South Coastal subregion possesses an excellent multimodal transportation system. This system includes an extensive limited access freeway network, three international airports, several inter- and intra-state airports, the major port of Los Angeles-Long Beach harbors, San Diego Harbor and Port Hueneme.

U.S. Highway 101A and State Highway 1, which has been designated a scenic highway, provide access to the shoreline areas for the entire reach of the subregion. Bus and train services are provided throughout the subregion and fulfill the need for supplemental transportation.

Existing Conditions in the Shoreline Zone

GENERAL

The study area covered by this report is confined to the band of shoreline considered to be the active erosive zone during the study period. This zone is assumed to be the 500 feet shoreward of the mean water line or to the upper limits of the existing beach, whichever is

greater. This does not insinuate that the entire zone will be eroded during the study period, rather that this is the minimum practical width to consider in a plan which will include the construction and stabilization of recreation beaches, the protection of structures threatened by erosion, and the general prevention of the loss of coastal land by ocean-caused erosion.

Existing beaches vary from the 900-foot-wide structurally stabilized beach at Santa Monica to rocky, pocket beaches that are inundated at the higher tides. Shoreline characteristics are shown in Map 2.

DESCRIPTION OF THE SHORELINE

General

Of the 233 miles of subregional shoreline, about 27 miles are considered to be non-erodible or stable. The remaining 206 miles of shoreline are being eroded at varying rates. About 163 miles of the eroding shoreline are considered to be undergoing critical erosion. This erosion is presently threatening (or is likely to threaten in the future) structures such as highways or residences, or is causing excessive loss of recreational beach area. Erosion rates as high as 8 feet a year have been observed. Erosion characteristics are shown in Map 5. The following paragraphs describe the shoreline topography and related problems by counties, from north to south. Major locations are shown on Maps SC-1 through SC-4, at the end of this chapter.

Ventura County

The mainland shoreline of Ventura County is about 41 miles long, which is 17.6 percent of the subregion's mainland shoreline. From the county line, at Rincon Point, 13 miles southeasterly to Ventura the shoreline is closely bordered by mountains of the Santa Ynez Range. U.S. Highway No. 101 and the Southern Pacific Railroad parallel the shoreline through this reach and occupy the narrow bench at the base of the mountains. Nearly 9 miles of stone rubble revetment, seawall, and bulkheads have been placed along this section for the protection of the highway and railroad. The County and State each have three beach park areas totalling 1.6 miles and 4.8 miles, respectively. Most of the beaches along this reach are covered with exposed cobbles, although in some areas there is a thin surface covering of sand. The backshore in most of the area is 30 to 50 feet wide; at some points there is no usable beach at high tide. Intermittent streams with steep slopes, draining about 59 square miles of the Santa Ynez Mountains, contribute about 30,000 cubic yards of sediment to the beaches in this segment on an average annual basis. The beaches are primarily nourished, however, by the littoral current, which delivers about 300,000 cubic yards per year to this reach.

Littoral flow is predominantly downcoast, except for occasional reversals caused by local seas coming from south to southeast, and storm waves coming through the Anacapa Passage.

From the city of Ventura, 20.7 miles to Point Mugu, the shoreline traverses the broad plain of the Santa Clara River. The mouth of the Ventura River is immediately upcoast from the city of Ventura. This intermittent stream has a drainage area of about 228 square miles, of which about 131 square miles have no stream control structures. During moderate to heavy discharges, the river-borne sediment forms a delta that, when eroded by the ocean waves, provides nourishment to the downcoast beaches. Prior to construction of the controlling dams, the average annual sand discharge to the beaches was from 160,000 to 210,000 cubic yards. Present annual discharge of sand varies from 90,000 to 120,000 cubic yards.

The shoreline from the Ventura River to the Santa Clara River, a distance of 4 miles, has been highly active, with alternating seaward prograding and recession. From 1948 to 1961, the net shoreward movement was about 300 feet. This beach was stabilized by the construction of a groin system during the years 1962 to 1967. Prior to the completion of Castaic Dam, the Santa Clara River had an uncontrolled drainage area of 1,165 square miles, and an average annual sand discharge of from 530,000 to 700,000 cubic yards a year. The dam reduced the drainage area to 1,011 square miles, and the average discharge to from 470,000 to 620,000 cubic yards a year. The variability of the natural sand supply can be illustrated by the fact that the storm in February 1969 produced an estimated 13,000,000 cubic yards of sedimentary material which the Santa Clara River carried to the coast. This was equal to 26 years supply in 2 weeks.

The county's major population centers of Ventura and Oxnard are located in the Santa Clara River plain. Two state beaches with 4.5 miles; 5 county beaches with 7.1 miles; and two city beaches with 2.2 miles comprise that portion of shoreline open to the public. Although there is 1 mile of revetment in this section, the beaches are generally from 100 to 400 feet in width. San Buenaventura State Beach has been stabilized with groins. The entrance jetties and breakwaters for the Ventura Marina, Channel Islands Harbor, and Port Hueneme are major shoreline structures in this reach. The last 6 miles of this section include Point Mugu Naval Reservation and the Mugu Lagoon, which are closed to the public.

Mugu Lagoon, part of the Point Mugu Pacific Missile Range, is one of several estuarine areas in Southern California that remain suitable for wildlife preservation. This lagoon receives heavy birdlife use from various marsh and lagoon species, shore birds, cormorants and pelicans. There is believed to be somewhat of a problem in respect to water contamination with pesticides resulting from surface runoff

from adjacent agricultural areas. This could have an adverse effect on the living resources in the lagoon.

The prevailing direction of littoral transport is downcoast in this segment. Ventura Marina has been subject to shoaling since its completion and frequent maintenance dredging has been required. An authorized Federal small-craft harbor project is under construction (1971) at Ventura Marina. This project involves construction of an offshore breakwater, a sand trap and a sand bypassing system. Channel Islands Harbor and Port Hueneme have a sand bypassing system in operation. Sand is trapped at Channel Islands Harbor, bypassed and deposited downcoast of Port Hueneme Harbor and the submarine canyon at that harbor. This sand bypassing has averaged 1,200,000 cubic yards a year, but is expected to stabilize at about 1,000,000 cubic yards a year.

From Port Hueneme to Mugu Lagoon and Point Mugu, the beaches are generally wide and, except for some problem areas, have been relatively stable. This recent stability is the result of placement of over 6,000,000 cubic yards of sand from construction of Channel Islands Harbor in 1960-61 and biennial sand bypassing since that time.

The 7 miles from Point Mugu to the Los Angeles County line are backed by the Santa Monica Mountains. The first 3 miles are within the Point Mugu State Recreation Area and includes the 300-foot-wide, 1-mile-long Sycamore Beach. The remainder is under private ownership and is fronted by beaches 25 to 100 feet wide. Behind the beaches, U.S. Highway No. 101 parallels the shoreline against the base of the mountains. It is protected by groins and sections of seawall.

In December 1969, heavy waves caused localized damage at several spots along the Ventura County coast. The affected areas were Rincon, La Conchita, Sea Cliff and Solimar Beach, all upcoast from the city of Ventura; Oxnard Shores, which is between the Santa Clara River and Channel Islands Harbor; and Point Mugu. Damage in most areas was caused by high surf that breached the beach berm. Damage to private property amounted to $448,000. About $415,000 was spent on emergency work required to protect property.

Los Angeles County

The mainland shoreline of Los Angeles County is about 74 miles long, which is 32 percent of the subregion's mainland shoreline. In the 28-mile-long segment from the Ventura County line to the city of Santa Monica, the Santa Monica Mountains closely back the shoreline. State Highway No. 1 parallels the shoreline about 100 to 200 feet inland through most of this segment except at Point Dume where the highway swings inland. A small privately-owned beach, Paradise Cove, lies just downcoast from Point Dume. This site is being considered

for a future small-craft harbor development. There are 6.8 miles of State beaches in this segment and 1.5 miles of County beach. Leo Carrillo Beach State Park has good overnight camping facilities; the other beaches are day-use areas. Existing sand beaches vary from pocket beaches less than 50 feet wide to the 3-mile-long, groin-stabilized Will Rogers Beach State Park. This reach has about 19.5 miles of private shoreline; about 11 miles has residential development consisting of a single row of dwellings on the beach seaward of the highway. Public access to the beach is extremely limited in the privately-owned shoreline. Several miles of the highway are at elevations of 100 to 200 feet, and provide scenic ocean views to the driving public.

The segment contains many areas noted for consistently good recreational surfing. Full recreational use of the beaches during the summer months is inhibited by deficient parking facilities and traffic congestion on State Highway No. 1, and lack of access to the beach. There is also a very small lagoon at the mouth of Malibu Creek that is popular for birdwatching. The lagoon's ecologic value has been reduced by grading operations and sewage contamination. The recent history in respect to erosion problems in the segment is as follows. Leo Carrillo State Beach (at Sequit Point) and Zuma Beach (1.1 miles upcoast of Point Dume) receive sand from natural tributary sources, and although beach widths have fluctuated, they have had no severe erosion problems. However, Point Dume Beach State Park on the immediate upcoast side of Point Dume has eroded to the extent that the access road is closed to the public. Further downcoast, Corral, Las Tunas, and Topanga beaches have erosion problems. Some efforts have been made to control this erosion with groins, or other means, but these have not been effective. A small beach erosion control study is now underway for Las Tunas Beach.

During a storm occurring in January 1959, damage resulted to beaches and property in the segment between Zuma Beach County Park and Santa Monica. Shoreline recession at Zuma Beach was estimated at 50 feet in one day, but no property was destroyed. In the Escondido-Malibu-Los Flores area, damage occurred to private property. Two houses were destroyed, 25 were damaged, and bulkheads were destroyed or damaged. Damage approximated $750,000. The Malibu area was threatened again in February 1966, but emergency work was able to avert all but minor damage.

Two problems not relating to shoreline erosion are significant in this reach. In the downcoast portion of the segment, from the community of Malibu to the city of Santa Monica, the landward side of the coast highway is faced by steep, eroded bluffs. Many expensive homes have been constructed on top of the bluffs, which are notoriously unstable. Over the years, numerous homes have been destroyed by landslides. The highway, also, has frequently been blocked by these slides. The State of California Division of Highways is studying

alternative plans to develop this highway to full freeway standards, and to relocate the highway so that it will not be vulnerable to slides. The alternative alignments that have been suggested are an offshore causeway, a relocation along the shoreline, and an inland alignment. Another problem in this segment is that of tideland ownership and beach access. The exclusive beach communities along the Malibu strip completely fence off the beach. A few public access rights-of-way exist; however, these have been closed off by property owners. The beach is so narrow, in any event, that little or no dry sand area is available at high tide.

From the city of Santa Monica to the Palos Verdes Peninsula, a distance of about 17 miles, the broad crescent beaches of the Santa Monica Bay front the Los Angeles coastal plain. The upland is in dense urban use; and, although State Highway No. 1 turns inland through most of this segment, the local street grid provides excellent access to the shoreline. There are 11.7 miles of State beaches in this segment, and 0.4 mile of County beach. About 4.3 miles of shoreline is privately owned, but public use of the beaches is permitted. The remaining 0.8 mile of shoreline comprises harbor facilities at Marina del Rey and King Harbor, at Redondo Beach. The beaches are broad and quite stable as a result of considerable artificial replenishment and stabilization, which has included the placement of over 20 million cubic yards of sand and the construction of numerous groins and three breakwaters.

The Santa Monica Breakwater, which is in a poor state of repair, was originally built to provide a small-boat harbor; however, it presently functions as a sand trap depriving the Santa Monica and Venice beaches of sand supply. Downcoast of Venice Beach are the Marina del Rey jetties and offshore breakwater, and the Ballona Creek jetty. So far, the jetties and offshore breakwater have not caused any significant effect along the downcoast beaches of Dockweiler, El Porto, Manhattan, and Hermosa; however, sand bypassing may eventually be required. Severe local damage occurred in the past at Redondo Beach. Much of this area is now protected by the King Harbor breakwater. A protective beach, stabilized by a barrier groin, was completed downcoast from the harbor in 1969.

The beaches of Santa Monica Bay are all good to excellent swimming beach. Located as they are, fronting the largest metropolitan area in California, they receive extremely heavy use. The major deficiency, in respect to public use of these beaches, is lack of adequate parking and support facilities. Amenities such as landscaped picnic areas, play areas, shower rooms, and such, would add to the recreational potential.

The segment around Palos Verdes Peninsula to the start of Los Angeles Harbor is about 17 miles long. Palos Verdes Peninsula is

a bold headland fronted by vertical seacliffs. The shoreline is rocky, interspersed with small pocket beaches less than 75 feet wide. The top of the peninsula is relatively level, and is becoming increasingly residential. Expensive ocean view homes occupy much of the 13.6 miles of privately-owned frontage. The Palos Verdes area is unusually scenic, and a roadway runs fairly close to the ocean around most of the peninsula. There are few public vista sites; however, the Coast Guard Station at Point Vicente and Marineland of the Pacific, an aquarium and recreation area, are open to public access and provide excellent viewpoints. In the downcoast part of the segment, Point Fermin Park, a county park, extends along the top of bluffs for about a mile. This park is attractively landscaped and affords a fine view of the shoreline and the active commercial port at Los Angeles-Long Beach harbors.

Except for Royal Palms State Beach. 0.6 mile, and Cabrillo Beach, 0.5 mile long, there are no public areas with access to the beach. The seacliffs along the peninsula are unstable in some areas, and slides in the past have caused the loss of houses and other properties with damages totalling millions of dollars.

The segment from the start of Los Angeles Harbor to the Los Angeles County-Orange County line is 12 miles long. Almost 7 miles of this segment is occupied by the major port facilities of Los Angeles-Long Beach harbors. The shoreline is protected from wave energy by the harbor breakwaters, and is comprised largely of revetment, quays, and bulkheads forming the port's terminal facilities. A portion of Cabrillo Beach lies within the port area; this beach was constructed with selected dredge spoil and is heavily used by local residents. Cabrillo Beach has good parking, a small natural museum, and is the starting point for shore walks along the rocky tidepool area fronting Palos Verdes peninsula between the breakwater and Point Fermin.

The interior of Los Angeles-Long Beach harbors has no shoreline erosion problems; however, serious water quality problems, particularly in Los Angeles Inner Harbor, have had a deleterious effect on procreation of fish, aesthetics, and recreational boating. The harbors are a major regional port, and handled 33 million tons of waterborne commerce in 1965. The harbors also provide terminals for sport fishing and commercial-fishing vessels, and commercial-recreational facilities such as shopping and restaurant complexes.

The final 5-mile-long segment of the shoreline, from the Los Angeles River to the Orange County boundary, is fronted by stable beach 200 to 500 feet wide. The upland land use is urban. Most of the beach is open to public use and, within the city of Long Beach, much of the backshore area is attractively developed in parks. These beaches are sheltered by the harbor breakwaters and the Alamitos Bay jetties, and are not subject to erosion.

Orange County

Orange County has a shoreline length of about 42 miles, which is 18 percent of the subregion's mainland shoreline. From the northern county line at the mouth of the San Gabriel River to the entrance of Newport Harbor, a distance of about 18 miles, the shoreline is sandy beach, backed by low alluvial valley, bays and marshes. From the entrance of Newport Harbor to the southern county line near San Mateo Point, a distance of about 24 miles, the shoreline is backed by cliffs. The foreshore is generally rocky, interspersed with pocket beaches. U.S. Highway No. 1 is close to the shoreline throughout the county. The county's shoreline is described by segments from north to south in the following paragraphs.

The segment of shoreline from the San Gabriel River to the entrance of Anaheim Bay is about 1.5 miles long. From the downcoast jetty of the river to the upcoast entrance jetty of Anaheim Bay Harbor, there is a continuous, publicly-owned beach, broken only by the Seal Beach pier and a groin. The fillet upcoast from the groin is very wide at the river jetty, and considerably narrower at the groin. Downcoast from the groin, the beach is quite stable. Anaheim Bay Harbor serves the U.S. Naval Weapons Station at Los Alamitos, and also provides the only access to the sea for the interconnecting system of waterways, marshes, and tidal flats that comprise Anaheim, Sunset and Bolsa Bays. These bays extend about 5 miles downcoast from Anaheim Bay, and are separated from the ocean by a sandy peninsula. Most of the marshy areas in Anaheim Bay are within the Los Alamitos Naval Weapons Station, and public access is prohibited. This area receives heavy bird use by various marsh and lagoon species, and is a resting ground for migratory waterfowl. Most of Sunset Bay has been developed as a residential marina and boating complex. Waterways have been dredged and land created through filling. The perimeters of the waterways are formed by vertical concrete bulkheads. Bolsa Bay, the most southerly of the interconnected bays, has been diked off in many places to protect existing oil wells. A narrow strip along the west is suitable for wildlife, and receives moderate to heavy use by lagoon species. Development of additional recreational-boating facilities have been proposed for Sunset and Bolsa Bays.

The shoreline from the downcoast entrance jetty of Anaheim Bay Harbor to the Newport pier is 12.5 miles of nearly continuous sand beach. All but 2.3 miles are public. The Surfside-Sunset Beach area, which is 1.7 miles long, contains the beach communities of Surfside, Sunset Beach, and Los Patos. Beach homes occupy the area between the beach and the State highway. Bolsa Chica State Beach, immediately downcoast, is a 3-mile stretch of straight beach, backed by Bolsa Bay. The State beach has extensive parking areas, filling the strip between the beach and the highway. The 2.3-mile reach below Bolsa Chica State Beach is privately owned and is used for

oil production; however, the beach is accessible to the public at either end; beach facilities are maintained by the city of Huntington Beach. Between this private beach and the mouth of the Santa Ana River, a distance of 3.4 miles, the shoreline is publicly owned; 1.1 miles are city beach; 2.1 miles are state beach; and 0.2 mile is the mouth of the Santa Ana River. The upland area on the landward side of the highway is urban, comprising the city of Huntington Beach. The beaches and their service facilities abut the seaward side of the highway. From the Santa Ana River to the entrance to Newport Bay Harbor, 5.5 miles, the beach is owned by the city of Newport Beach. The area behind the beach is densely developed with homes, the first row of which fronts the sand.

The shoreline from Anaheim Bay Harbor to Newport pier, about 15 miles in all, is eroding. Beach erosion in the vicinity of Newport Beach has been spectacularly violent on several occasions. During a storm in August 1965, for instance, the protective beach along a 30-block stretch of Newport Beach was severely eroded. The beach eroded to within 5 feet of the houses before emergency measures were effective. These beaches have historically been nourished by sand brought down from the mountains by major rivers and streams. In the last few decades, the local need for water and the demand for flood protection has required that many of these rivers and their tributaries be dammed and channelized. A dry cycle in the climate has also contributed to the problem; and the beaches have been steadily retreating. It is estimated that the littoral current strips the beaches in this reach of 300,000 cubic yards of sand a year, and carries it south into the Newport submarine canyon. This creates a need for periodic artificial nourishment. The 2.8 miles of shoreline between the Newport pier and the entrance to Newport Bay is considered a separate littoral unit because of the Newport submarine canyon. Since the deposition of approximately 5,600,000 cubic yards of fill in this area in 1935, this wide beach has been relatively stable.

Newport Bay is one of the most popular resort areas in southern California. The bay is home port to over 4,000 permanently berthed boats and as many smaller boats. The shores and islands in lower Newport Bay are densely developed with high-priced residences, exclusive restaurants, yacht clubs, and shops. Upper Newport Bay (landward of State Highway No. 1) is presently fairly undeveloped. A public recreation area and a few small marinas are located near the State highway, but most of the upper bay is pristine. This 1,500 acres of open space is the largest natural bay and tideland area in the South Coastal subregion. It is an important habitat for many marine and tideland species, including waterfowl. More than 200 species of marine organisms, 60 species of fish and 160 species of birds are found in the bay. It is an important stopping place for waterfowl moving along the Pacific Flyway. A major residential marina and boating complex has been proposed in the Upper Newport; this proposal is bitterly opposed by conservation and fish and wildlife interests. A suit is now before

the courts to contest the legality of the land exchange upon which the development depends.

Most of the next 16 miles of shoreline are backed by 30 to 130-foot high bluffs; access to the beach is limited. Four miles are relatively undeveloped, and the remaining 12 miles, including the city of Laguna Beach, are residential, with houses built close to the edge of the bluffs. Laguna Beach has been a popular resort area and artists colony for many years. There has been no known property damage due to earth slides in this area. The beaches are essentially pocket beaches, and their stability has varied. In some areas, erosion has occurred and protective measures are required. There is a total of about 1 mile of public beach; other pocket beaches are scattered along the base of the cliffs throughout this reach and are accessible to public use. The newly-constructed small-craft harbor at Dana Point is in the last mile of this reach.

From Dana Point Harbor to the San Diego County line is a distance of about 8 miles. The northerly 1.2 miles of this reach comprise Doheny Beach State Park, which has a beach that varies from about 150 feet wide at the mouth of San Juan Creek to zero at the downcoast end, where the railroad embankment has required revetment. Doheny Beach has required structural shore-protection work. The next 2.6 miles of shoreline are private. The beach is about 30 feet wide, and has houses on the immediate landward side. This area also has been subject to erosion. The next 3.2 miles are publicly owned and comprise San Clemente city park and San Clemente State Beach. The beach is 50 to 100 feet wide. It is backed by the Atchison, Topeka and Santa Fe Railroad line, which runs along the base of the cliffs. Residential development is general along the top of bluffs landward of the railroad line. The final 0.8 mile of the Orange County shoreline is privately owned. Access to this area is difficult because of the railroad.

San Diego County

The shoreline length of San Diego County is about 76 miles, which is about 33 percent of the subregion's ocean shoreline. With the exception of about 11 miles, the county's shoreline is comprised of sandy swimming beach. The upcoast segment of shoreline extends from San Mateo Point to the mouth of the Santa Margarita River, a distance of 24 miles. This entire segment of shoreline is backed by the 60- to 150-foot high cliffs of the San Onofre Bluffs, which are cut by intermittent streams that drain to the ocean through V-shaped canyons. The beaches fronting the bluffs average 100 feet wide, and are wider at the stream mouths. Large masses of earth have slipped from the bluffs in many places along the shoreline. Some of these landslides have extended as far as 500 feet inland from the main beach. Beach material consists generally of well-sorted,

coarse river sand supplied from the many small streams that empty into the ocean along this shoreline. This entire shoreline segment is part of Camp Joseph H. Pendleton, and public use of the beach areas is not permitted, with the exception of about 3 miles at the northern end, which have been recently opened to public use. The beaches within Camp Pendleton are a potentially valuable recreational resource, when they become surplus to military needs. Camp Pendleton's Del Mar Boat Basin is at the southernmost limit of the reservation. Oceanside Harbor, a public small-craft harbor, is immediately adjacent to the reservation boundary and shares entrance jetties with the Del Mar Boat Basin.

From Oceanside Harbor to the city of Carlsbad, a distance of 4.5 miles, the shoreline is comprised of an eroding beach, with widths ranging from 75 to 200 feet. There is a nearly continuous line of residences along the beach seaward of the coastal highway. The beach downcoast from Oceanside Harbor has been replenished with material dredged to construct and maintain the harbor. This material was heavily interspersed with 2 to 4 inch cobbles; as the sand seaward of the berm line eroded, the cobbles became noticeable. The beach from the Oceanside Pier to Loma Alta Creek was almost completely denuded of sand. Part of the beach was restored in 1966 with dredged spoil from maintenance dredging; however, wave action again stripped the beach, exposing cobbles from the groin at the mouth of the San Luis Rey River downcoast to Loma Alta Creek. Although a cobblestone beach is not acceptable for bathing recreation, it does provide the needed protection against further shoreline erosion.

The segment from Loma Alta Creek to the north boundary of Torrey Pines State Reserve is about 16 miles long. The segment has numerous state- and county-owned beaches, and contains the beach communities of South Oceanside, Carlsbad, Encinitas, Cardiff-by-the-Sea, Solana Beach, and Del Mar. The shoreline zone between these communities is relatively uninhabited. The beaches in this segment are flat, clean beaches with attractive, gentle surf. The dry sand beach area is generally 100 feet wide or more. Low marine terrace formations back the beach, except at the river valleys; these valleys contain lagoons and marshes.

Seven of the San Diego County lagoons merit discussion. The most northerly, Buena Vista Lagoon, lies between the communities of South Oceanside and Carlsbad. Buena Vista Lagoon has an area of about 140 acres, and is a bird sanctuary. The lagoon is used by over 200 species of waterfowl. Agua Hedionda lies downcoast from the community of Carlsbad. Agua Hedionda was once a natural lagoon and marsh, but has been dredged to provide a cooling water intake for a power-generating plant. The periphery of the lagoon has been developed for boating and fishing recreation. There are about 90 acres of marshland at the inland end of the lagoon that provide some

habitat for wildlife, but the lagoon is not heavily used by waterfowl. Batequitos Lagoon is located just upcoast from the community of Leucadia. This is the most lake-like of all of the lagoons, and supports a moderate bay duck population. San Elijo Lagoon is a 500-acre undeveloped marsh area located south of the community of Cardiff-by-the-Sea. Many species of wintering and migratory waterfowl inhabit this area at various seasons. This marsh is entirely dependent upon inflow consisting of sewage effluent from surrounding communities. This source is expected to be terminated within the next few years. The valley of the San Dieguito River, at Del Mar, once provided a marsh area; however, in recent years, the marshes have largely dried up. The area does not have significant wildlife values. Los Penasquitos Lagoon is located about 3 miles further downcoast, in the Soledad Valley. The total area of this lagoon and salt marsh is 312 acres. About 100 acres is normally a dry salt pan. Torrey Pines State Reserve includes the western half of this lagoon, which is a resting ground for migratory waterfowl and a feeding ground for many resident species, including a wide variety of small mammals.

The segment from the north boundary of Torrey Pines State Reserve to the city of Pacific Beach is about 12 miles long. The reserve protects the world's only stand of this particular species of pine tree. Torrey Pines State Reserve and State Beach Park occupy 4.5 miles of the shoreline. There is also about 0.7 mile of public shoreline in the city of La Jolla. The Scripps Institute of Oceanography, a unit of the University of California, is located between Torrey Pines and La Jolla. Access to the shoreline is somewhat limited in the northern part of the segment; however, in the southern part of the segment, the street grid of the city of La Jolla provides excellent access. The shoreline area in La Jolla is rocky and extremely picturesque; the city is fronted by eroded seacliffs, sea caves, and a few sandy, pocket beaches. Residences are built along the tops of these cliffs and have spectacular views of the coast. The cliff material is easily eroded, and most of the sea caves, which once were a tourist attraction, have been closed in the interest of public safety. Undercutting of the cliffs by the sea has endangered residential property in some areas and protective measures have been required.

The segment comprising Mission Valley, between La Jolla and the Point Loma Peninsula, is fronted by about 4.5 miles of easily accessible recreational beach. Pacific Beach and Mission Beach are the major beaches. The jettied entrance to Mission Bay is in this segment. Mission Bay was once a natural bay and marshy area, but has been extensively dredged and filled to form an aquatic park with an area of about 4,000 acres, of which 2,000 acres are water. Extensive resort, recreational, and boating facilities are provided within the park.

Point Loma rises from the valley as a continuation of the La Jolla Mesa. Its shoreline length is about 8 miles, of which over 5 miles are Federally-owned and are not open to the public. Ocean Beach, at the north end of Point Loma, is about 0.6 mile long. It is bordered on the north by the south jetty of the San Diego River and on the south by cliffs. The beach averages about 400 feet wide at the river, but narrows to less than 30 feet at the southern end. Ocean Beach has been subject to erosion, and protective measures-- consisting of seawall, a groin, and placement of beach fill-- have been required. The Sunset Cliffs area, which fronts part of the community of Ocean Beach on Point Loma, extends approximately 3 miles. The Sunset Cliffs shoreline is similar to the La Jolla shoreline and is composed of wave-cut cliffs, pocket beaches, and sea caves. Undercutting of the cliffs has endangered residential property.

The entrance to San Diego Bay, marked at the north by Ballast Point and on the south by Zuniga Jetty, lies just downcoast from Point Loma. San Diego Bay provides a commercial harbor, a home port for the Pacific Fleet of the U.S. Navy, and marinas for many recreational boats. The south part of the bay is shallow and has extensive tidal areas, which support some 180 species of birds, as well as varieties of unique salt water plants. In recent years, a major effort has been made to clean the waters of San Diego Bay through construction of a sewage collection system and a major offshore outfall line. This effort is succeeding and swimming is now permitted in many areas of the bay. There are no erosion problems of note along the bay's perimeter.

San Diego Bay is cut off from the ocean by a long sand spit, the Silver Strand, that extends downcoast to the valley of the Tijuana River, which marks the south boundary of the county, the downcoast limit of the South Coastal subregion, and the international boundary between the United States and Mexico. This segment is 13.8 miles long. About 4.7 miles are Federally-owned, including the San Diego Naval Air Station on North Island, the Naval Radio Station, and Border Field Naval Reservation. The U.S. Navy also leases about 2.5 miles of Silver Strand State Park. The remainder of the segment's shoreline, all of which is swimming beach, is open to public use. Coronado Beach, toward the upcoast end of the segment, has been protected by seawall and a groin, and has been nourished with material dredged from San Diego Bay. Silver Strand State Beach has also been nourished from the same source. This beach material is being slowly removed by waves and longshore current action. The beach fronting the city of Imperial Beach, which lies just north of the Tijuana River, varies from 100 to 200 feet in width. In the southern section, it is backed by lagoons and marshy areas witha tidal area of about 600 acres. The beach has required protective measures to alleviate erosion. The beaches of this segment held by the U.S. Navy are a potentially valuable recreational resource, should they become surplus to military needs.

The Islands

The five Channel Islands that are within the South Coastal subregion are Anacapa and San Nicolas (Ventura County), and Santa Barbara, San Clemente, and Santa Catalina Islands (Los Angeles County).

Anacapa and Santa Barbara Islands, together, comprise Channel Islands National Monument, which is under the jurisdiction of the National Park Service. Anacapa, comprising 700 acres, is really a slender chain of islands about 5 miles long and half a mile wide. Anacapa is characterized by high seacliffs, inhabited by many sea birds. Sea lions frequent the islands, and sea elephant and sea otters visit occasionally. Santa Barbara Island contains 650 acres. The island is girdled by almost vertical cliffs up to more than 500 feet in height. Small rocky bays and occasional sandy beaches offer excellent habitats for marine mammals. Numerous caves, offshore rocks, and spout holes create dramatic seascapes. Access to these two islands is by private or chartered boat. The rugged, rocky shorelines of the islands afford some semi-protected anchorage for small craft, but there are no improved landing facilities.

San Nicolas and San Clemente Islands are owned and used by the United States Navy. Both are closed to all public use. A small Navy landing at San Nicolas Island has required maintenance dredging periodically to alleviate shoaling problems. Neither island is included in the National Park Service's future plan for expansion of Channel Islands National Monument into a National Park comprising five islands. The three islands suggested for inclusion are Santa Cruz, Santa Rosa, and San Miguel; all are within the Central Coastal subregion.

The remaining island, Santa Catalina Island, is privately owned, but has been developed as a resort area for many years. The island has an area of about 75 square miles, is 18.5 miles long, and has a maximum width of 7 miles. Santa Catalina is rugged and mountainous, and generally has a steep, precipitous shoreline. The lee side of the island, facing the mainland, is protected from wave action during prevailing sea conditions, and affords many sheltered, pebbly beaches at the mouths of the canyons. The leeward side also has many coves that are heavily used by small craft; the windward side has one small cove and one large, well-protected, natural harbor. Public access to the island's shoreline is permitted upon payment of a fee. Avalon, the principal settlement on the island, is owned by the county of Los Angeles and is an incorporated city with a permanent population of about 1,700. The city of Avalon is the only part of the island with significant shoreline erosion problems. During Santa Ana wind conditions, when the wind blows off the mainland shore, the side of Santa Catalina facing the mainland can be subject to high wave action. The bay at Avalon has been protected by two short breakwaters,

sea wall, and revetment. The breakwaters, which were completed in 1969, do not afford protection to much of the shoreline. Facilities within Avalon Bay have been damaged on many occasions in the past. The present breadwaters already extend into water 90 feet deep, and extension of these structures to provide more protection would not be economical.

LAND USE

Upland land use is predominantly urban in this subregion. About 59 percent of the mainland shoreline zone is in this category, considering the subregion as a whole. Los Angeles County is the most urban, with 81 percent of its shoreline zone in urban uses. Ventura County is the least urban, with 32 percent of its shoreline in urban uses. Military uses occupy about 16 percent of the subregion's shoreline zone; military uses are particulary significant in San Diego County, where they occupy almost 39 percent of that county's shoreline zone. Other land uses, ranked in decreasing order, are public reserves, 10 percent; harbors,4 percent; and agricultural, 4 percent. Other miscellaneous uses include U.S. Coast Guard lighthouses, educational institutions, flood-control channels and river mouths, and undeveloped areas. The urban areas in Los Angeles County, particularly, are dense, and include commercial, industrial and residential developments. Urban areas in the other counties trend more toward residential. Land uses, by categories, are summarized in the following tabulation, and are shown on Map 3.

County	Land use, in shoreline miles						
	Urban	Agri-culture	Military	Public Reserve	Harbors	Other	Total
Ventura	13.2	3.8	6.2*	7.5	0.9	9.6	41.2
Los Angeles	59.9	3.2	0.8	1.0	6.8	2.2	73.9
Orange	27.9	0	0	7.8	1.0	5.2	41.9
San Diego	33.5	2.2	29.3*	6.8	1.5	2.7	76.0
Total	134.5	9.2	36.3	23.1	10.2	19.7	233.0
Islands	1.0	0	103.0	20.0	0	85.0	209.0

* Includes military use of about 6 miles of shoreline leased from non-Federal agencies.

OWNERSHIP

In 1965, about 15 percent of the subregion's mainland shoreline zone was Federally owned; 25 percent was owned by the State; 16 percent was owned by local governmental bodies; and the remaining 44 percent was privately owned. The Federally-owned shoreline included military reservations and U.S. Coast Guard Facilities. The shoreline owned by the State and local governments was largely recreational. Ownership is summarized in the following tabulation and is shown on Map 3.

County	Land ownership, in shoreline miles					
	Public				Private	Total
	Federal	State	Local	Subtotal		
Ventura	4.8	12.6	11.0	28.4	12.8	41.2
Los Angeles	1.2	19.5	12.7	33.4	40.5	73.9
Orange	0.7	10.0	12.3	23.0	18.9	41.9
San Diego	28.1	16.7	1.1	45.9	30.1	76.0
Total	34.8	58.8	37.1	130.7	102.3	233.0
Islands	123.0	0	1.0	124.0	85.0	209.0

RECREATIONAL SHORELINE

Most of the publicly-owned recreational beach in the subregion is classified as swimming beach. There are a few beaches in Ventura County that are classified as non-swimming beaches because they are rocky. Natural scenic shoreline is comprised of parts of Point Mugu State Recreation Area and Torrey Pines State Park; and the Channel Islands National Monument, comprised of Anacapa and Santa Barbara Islands. Recreational and scenic shoreline available in 1965 is summarized in the following tabulation, and is shown on Map 4.

County	Recreational and scenic shoreline, in miles		
	Swimming beach	Non-swimming beach	Scenic shoreline
Ventura	22.7	0.9	3.1
Los Angeles	20.8	0.4	0
Orange	22.0	0	0
San Diego	17.5	0	3.9
Total	83.0	1.3	7.0
Islands	0	0	20

EROSION CHARACTERISTICS

Geologically speaking, essentially the entire shoreline is eroding to some degree. However, for the purpose of this report, erosion characteristics have been classified into three categories -- critical erosion, non-critical erosion, and non-eroding. These categories are defined in the Introduction. The erosion characteristics of the subregion's mainland shoreline were estimated from historic trends, and data from available reports and studies. The character of shoreline formations, wave energies, littoral transport conditions, and existing structures in the active erosive zone were considered. Over 88 percent of the shoreline is eroding; 70 percent of the shoreline is eroding at a critical rate. The 12 percent of the shoreline that is not eroding is comprised of river and channel mouths, resistant rock, or shoreline protected by structures. Erosion rates in the subregion range from zero for non-eroding shoreline to as high as 8 feet a year in the most critically eroding area. This subregion, fronted mostly by sandy beach and highly urbanized, is more vulnerable to erosion damage than any of the other subregions. Erosion characteristics along the mainland shoreline are summarized in the following tabulation, and are shown on Map 5.

County	Erosion characteristics, in miles			
	Critical	Non-critical	Non-eroding	Total
Ventura	23.2	16.5	1.5	41.2
Los Angeles	52.0	2.5	19.4	73.9
Orange	37.2	1.7	3.0	41.9
San Diego	50.7	22.3	3.0	76.0
Total	163.1	43.0	26.9	233.0

PROTECTIVE AND MITIGATIVE EFFORTS

General

The term "protection," as used in this report, refers to both structural and non-structural measures for the reduction of damages caused by shoreline erosion and tsunamis. Structural measures include such works as stabilization and beach fill, seawall and revetment, and periodic replenishment of existing beaches. Non-structural measures include zoning and regulating the use of the shoreline zone. The term "development" refers to the creation of new beaches and acquisition of shoreline for public recreational use. Protective and mitigative efforts undertaken to date along the subregion's shoreline include, primarily, structural measures. This work has been done under authorized Federal projects, by non-Federal public agencies, and by private property owners. Accomplishments relating to these activities are discussed in the following paragraphs.

Federal Projects

The authorities under which Federal beach erosion control and shore protection projects may be undertaken are described in the Regional Summary. Ten Federal projects have been authorized within the South Coastal subregion. These projects are as follows:

Project	Location
Ventura Beach	Ventura County
Point Mugu to San Pedro Breakwater	Los Angeles County
Anaheim Bay Harbor	Orange County
San Gabriel River to Newport Bay	Orange County
Doheny Beach State Park	Orange County
Oceanside	San Diego County
Ocean Beach	San Diego County
Bird Rock Area of La Jolla	San Diego County
San Diego (Sunset Cliffs)	San Diego County
Imperial Beach	San Diego County

Work authorized, completed, and remaining to be done under these authorized projects is summarized in the following table:

Project	Project features			
	Groins (No.)	Protective beach Length (Mi.)	Fill (1,000 cu.yds.)	Other (Mi.)
Ventura Beach				
Authorized	7	2.1	1,740	0
Completed (30 June 1965)	5(a)	1.6	721	
Completed (1965-1970)	2	0.1	162	
Balance	0	0.4	857	
Point Mugu to San Pedro Breakwater				
Authorized	2	5.7	4,239	0
Completed (30 June 1965)	1	0	0	
Completed (1965-1970)	0	1.5	1,400	
Balance	1	4.2	2,839	
Anaheim Bay Harbor				
Authorized	1	0.5	225	0
Completed (30 June 1965)	1	0.5	225	
Balance	0	0	0	
San Gabriel River to Newport Bay				
Authorized	4	2.5(b)	5,126(c)	0.5(d)
Completed (30 June 1965)	0	2.0	4,000	0
Completed (1965-1970)	(e)	0.1	493	0
Balance	4	0.4	633	0.5
Doheny Beach State Park				
Authorized	1	1.1	934(f)	0
Completed (30 June 1965)	0	0	0	
Completed (1965-1970)	1	1.1	934	
Balance	0	0	0	
Oceanside				
Authorized	1	3.3	3,600	0
Completed (30 June 1965)	1	3.3	3,600	
Balance	0	0	0	
Ocean Beach				
Authorized	1	0.3	275	0
Completed (30 June 1965)	1	0.3	275(g)	
Balance	0	0	0	

Project	Project features			
	Groins (No.)	Protective beach Length (Mi.)	Fill (1,000 cu.yds.)	Other (Mi.)
Bird Rock Area of La Jolla				
Authorized	0	0	0	0.2(h)
Completed (30 June 1965)				0
Completed (1965-1970)				0.2
Balance				0
San Diego (Sunset Cliffs)				
Authorized (1966)	4	0.8	720	1.3(i)
Completed	0	0	0	0
Balance	4	0.8	720	1.3
Imperial Beach				
Authorized	5	0	0	0
Completed (30 June 1965)	2			
Completed (1965-1970)	0			
Balance	3			
Total, subregion				
Authorized	26	16.3	16,859	2.0
Completed (30 June 1965)	11	7.7	8,821	0
Completed (1965-1970)	3	2.8	2,989	0.2
Total completed (to 1970)	14	10.5	11,810	0.2
Balance	12	5.8	5,049	1.8

(a) One of the five groins was abandoned.
(b) Including 1.9 miles of feeder beach.
(c) Periodic average annual nourishment of 350,000 cubic yards also authorized.
(d) Offshore breakwater.
(e) A steel test groin was completed in 1968.
(f) Periodic average annual nourishment of 23,000 cubic yards also authorized.
(g) Periodic average annual nourishment of 5,000 cubic yards also authorized.
(h) Revetment.
(i) Revetment, dikes, and sealing cave entrances.

Mitigation of shoreline erosion problems has also resulted from Federal harbor projects, both from harbor construction and from maintenance dredging. At Ventura Marina, which is a Federal maintenance project, sand dredged to maintain the harbor channels is placed on the beach south of the harbor jetties to nourish the downdrift beaches. At Channel Islands Harbor, which is a Federal small-craft harbor project, an average of about 1,200,000 cubic yards a year of material are bypassed to nourish the downdrift beaches. Oceanside Harbor, a Federal maintenance project, has also required frequent maintenance dredging; material is placed to nourish Oceanside Beach, located south of the harbor. Material was also placed in the littoral transport zone during construction of these harbors. About 6,240,000 cubic yards of material was placed on the beach for shore protection when Channel Islands Harbor was constructed. Other Federal navigation work, comprising U.S. Navy dredging, has added another 6,000,000 cubic yards to the littoral zone.

On 27 July 1946, the State Division of Beaches and Parks made formal application for a continuing cooperative Federal-State study of the entire Pacific Coast shoreline of the State of California. Many sites in the subregion have been surveyed under this program. Additional studies are continuing informally, involving collection of data at state beaches along the entire shoreline of the subregion.

Non-Federal and Private Work

Over an extended period of time, considerable beach protection and development work within the subregion has been done by various non-Federal agencies, including state, county and city agencies, and by private owners. It is difficult to trace the history of these improvements with certainty; however, it is estimated that about 55 groins have been constructed and about 25,000,000 cubic yards of beach fill have been placed. About 80 to 85 percent of this work has been done in Los Angeles County. In addition to this work to stabilize the sandy beaches of the subregion, the State Division of Highways has constructed considerable revetment and seawall to protect U.S. Highway No. 101, the Pacific Coast Highway, along a 10-mile reach of shoreline in Ventura and Los Angeles Counties. In Ventura County, revetment has been placed to protect oil well foundations from erosion. At Santa Catalina Island, virtually the entire 1-mile-long perimeter of Avalon Bay has been protected by seawall and revetment. It is estimated that a minimum of 75 groins of varying quality and effectiveness have been constructed by private interests to protect private-shoreline properties. As far as is known, no beach fill of consequence has been placed by private interests.

Non-structural Measures

The four counties in the subregion have all adopted general master plans or shoreline development plans. The counties and the

large coastal cities also recognize the need for management of the shoreline, but implementation is difficult under present legislative constraints. The major effort has been toward acquisition of public recreational shoreline as funds are available. The extremely high value of shoreline frontage in the subregion, ranging from $700 to $1,500 a front-foot, has constrained the acquisition program in recent years. Acquisition to date has been previously discussed.

SHORELINE EROSION DAMAGE, PRESENT CONDITIONS

Estimates of shoreline erosion damages, under present conditions, were based on land use, rate of erosion, and market value of shoreline property that is subject to erosion damage. A detailed explanation of the method used for evaluating erosion damage is given in the Regional Summary.

The estimated average annual shoreline erosion damages, under present conditions, are shown in the following tabulation.

County	Average annual shoreline erosion damage, in $1,000
Ventura	$ 680
Los Angeles	860
Orange	2,310
San Diego	1,360
Total	$5,210

Future Needs in the Shoreline Zone

GENERAL

Future needs are evaluated in terms of reducing shoreline erosion damages and meeting the needs for recreational shoreline, including conservation of scenic shoreline. A detailed explanation of the method used to evaluate erosion damages, and the means whereby these damages could be reduced is contained in the Regional Summary. The Regional Summary also contains a detailed explanation of the methods used to evaluate the needs for recreational shoreline.

SHORELINE EROSION DAMAGES, FUTURE CONDITIONS

The dollar value of future erosion damages were estimated by applying economic growth factors based upon population projections and related economic indices to data for the base year (1965). It was assumed that, on the average, erosion rates would remain constant and that no erosion control projects would be constructed during the study period. The average annual shoreline erosion damages for the South Coastal subregion, under present and future conditions, are shown in the following tabulation.

County	Average annual shoreline erosion damages, $1,000			
	1965	1980	2000	2020
Ventura	680	1,090	1,990	4,030
Los Angeles	860	1,240	1,960	3,020
Orange	2,310	4,000	7,240	10,420
San Diego	1,360	2,270	4,250	6,550
SUBREGION TOTAL	5,210	8,600	15,440	24,020

SHORELINE RECREATION NEEDS

Projected needs for recreational beaches are based on projections of population and related factors for the South Coastal subregion and adjacent inland subregions. Projected needs for conservation of scenic shoreline are based upon the availability of the resource and recommendations of the National Park Service, the State of California and other governmental entities. The projected requirements for public recreational shoreline in the South Coastal subregion are shown in the following tabulation.

County	Cumulative Public Recreational Shoreline Needs, in Miles			
	1965	1980	2000	2020
Ventura				
Swimming beach	1.4	3.4	8.4	14.8
Non-swimming beach	0.2	0.3	0.3	0.3
Scenic shoreline	3.0	3.0	3.0	3.0
Los Angeles				
Swimming beach	30.7[1/]	38.3	47.2	54.8
Non-swimming beach	1.0	1.6	3.2	4.0
Scenic shoreline	0	0	0	0
Orange				
Swimming beach	10.0	17.4	26.4	33.8
Non-swimming beach	0.1	0.2	0.3	0.4
Scenic shoreline	0	0	0	0
San Diego				
Swimming beach	5.9	7.9	13.0	17.6
Non-swimming beach	0.7	0.9	1.2	1.3
Scenic shoreline	4.0	4.0	4.0	4.0
SUBREGION TOTAL				
Swimming beach	48.0	67.0	95.0	121.0
Non-swimming beach	2.0	3.0	5.0	6.0
Scenic shoreline	7.0	7.0	7.0	7.0

1/ Of the 9.9 miles needed in excess of 1965 supply of 20.8 miles, 3 miles represent an actual deficiency. The remaining 6.6 mile need was met in adjacent counties.

Means to Satisfy Future Needs in Shoreline Zone

GENERAL

The shoreline program for the subregion includes structural and non-structural protective measures to reduce potential future damages, the development of additional swimming beach, and the acquisition of beaches for public recreational use.

STRUCTURAL MEASURES

In the development of the structural phase of the shore protection program, emphasis was placed on those urban and public recreational areas that are being threatened with critical erosion. Present encroachments into the active erosive zone are considerable in both extent and value; further, much of the shoreline zone is comprised of public recreation areas. There are 163 miles of the subregion's shoreline threatened by critical erosion. The only practical means of protecting much of this shoreline is through structural measures, such as beach stabilization, replenishment or revetment. Structural measures involving protective beaches would also provide, incidentally, additional beach area for recreation. About 32 miles of protective beach would be provided during the study period.

The subregion has a projected deficiency of public swimming beach. To meet a part of this deficiency, the shoreline program also proposes construction of new beaches either through peninsula extensions to the shoreline or through placement of beach material on the shoreline in reaches that do not presently have suitable beaches. About 20 miles of new beach would be constructed during the study period. Non-structural protection of eroding areas by means of shoreline management is discussed in subsequent paragraphs.

Table SC-1, at the end of this chapter, shows the projected scope, in miles, of potential shoreline protection and development projects for the subregion, by time frames.

NON-STRUCTURAL MEASURES

Non-structural measures would be of minimum effectiveness in this subregion, as compared to other subregions; however, in the shoreline reaches that are still relatively free from encroachments, management or other non-structural measures should be implemented in order to minimize erosion damages.

Several bills have been presented to the State Legislature that would establish State and regional commissions to deal with the problems associated with the conservation and development of the California coastal zone. These bills propose that the commissions would prepare

and adopt a comprehensive and long-range coastal zoning plan and criteria and standards for numerous environmental factors that could, if uncontrolled, detrimentally change or irreversibly modify the shoreline environment. Regulating land use to prevent structural encroachment into the erosive zone would come within these criteria and standards. However, such regional plan, by necessity, would be broad in scope and general in concept and probably would not contain a detailed inventory of the erosion characteristics of the shoreline. Therefore, the shoreline program presented herein includes a provision for a detailed study of the shoreline with respect to its erosive character so that definitive guidelines could be established for the non-structural reduction of potential future erosion damages.

At the Federal level, several bills have been introduced in Congress that would establish a policy of Federal participation with regard to the conservation and development of the Nation's coastal resources.

ACQUISITION OF RECREATIONAL SHORELINE

In addition to the 20 miles of new beach that would be created as a part of the structural program, additional beach shoreline would be made available through recreational use of shoreline that is presently publicly owned, but closed to public use. Other beach shoreline would be acquired through purchase. The program involves acquisition and/or public use of about 13 miles of shoreline in the study period. The total additional beach that would be provided through acquisition and development would amount to about 33 miles. No acquisition of scenic shoreline is proposed, since no undisturbed natural shoreline is available that is not already reserved in public ownership.

EFFECTIVENESS OF THE SHORELINE PROGRAM

As indicated in the tabulation on page SC-26 average annual shoreline erosion damages for the South Coastal subregion will increase from about $5.2 million in 1965 to $8.6 million by 1980, $15.4 million by 2000, and $24.0 million by 2020, if no measures to prevent erosion damages are implemented after 1965. If the shoreline program presented herein is fully implemented, the average annual erosion damages for the South Coastal subregion will decrease from about $5.2 million in 1965 to $3.7 million by 1980, $2.7 million by 2000 and $1.9 million by 2020. Table SC-2 summarizes the effectiveness of the shoreline protection and development program in reducing shoreline erosion damages in the subregion.

Publicly-owned recreational shoreline in the South Coastal subregion would increase from 91 shoreline miles to 125 shoreline miles. The unmet demand at the end of the study period would amount to about 5 miles of swimming beach and 4 miles of non-swimming beach. This

unmet demand reflects the high requirements for recreation in this densely-populated subregion, and the limited extent of the available or developable resource. Table SC-3 summarizes the extent of the shoreline available by types of shoreline and by time frames, if the program is implemented.

Implementation

BASES FOR COAST ESTIMATES

Estimates of cost for the shoreline protection and development program in the South Coastal subregion were based to a large extent on data from available reports and current studies, adjusted to reflect particular site conditions. Estimates of reconnaissance scope were made when existing data were not available. In general, unit costs were developed for each subregion for structural measures and applied to sites with similar characteristics. Estimated costs for acquisition of recreational shoreline were based upon prevailing land values for the particular area. Costs associated with non-structural measures to reduce potential shoreline erosion damages were based on the estimated cost of studies needed to establish necessary guidelines for regulation of land use within the shoreline erosive zone.

ESTIMATED SHORELINE PROGRAM COSTS

The estimated installation costs for the shoreline protection and development program in the South Coastal subregion amount to about $11.9 million for the 1966-1980 time frame, $18.2 million for the 1981-2000 time frame, and $19.8 million for the 2001-2020 time frame. These cost estimates do not include expenditures for access roads, or parking and sanitary facilities, which are included in Appendix XII: Recreation under the general categories of development and acquisition costs for recreation land Classes I and II. Cumulative annual maintenance cost estimates amount to $104,000, $348,000 and $544,000 for the respective time frames. All maintenance costs are the responsibility of local interests.

Table SC-4 summarizes the shoreline protection and development program estimated costs for the South Coastal subregion.

TABLE SC-1
SOUTH COASTAL SUBREGION
Potential Projects, in Miles

Item	1966-1980	1981-2000	2001-2020	Program Total
Ventura County				
Beach Stabilization	1.0	2.5	0	3.5
Seawalls	1.0	1.0	1.0	3.0
Beach Replenishment	1.0	0	0	1.0
Beach Development	0	0	0	0
Los Angeles County				
Beach Stabilization	3.5	5.0	2.0	10.5
Seawalls	0	0	0	0
Beach Replenishment	0	0	0	0
Beach Development	0	5.0	15.0	20.0
Orange County				
Beach Stabilization	5.0	6.0	2.0	13.0
Seawalls	0	0	0	0
Beach Replenishment	0	0	0	0
Beach Development	0	0	0	0
San Diego County				
Beach Stabilization	1.0	0	1.0	2.0
Seawalls	1.0	0	0	1.0
Beach Replenishment	0	2.0	0	2.0
Beach Development	0	0	0	0
SUBREGION TOTAL				
Beach Stabilization	10.5	13.5	5.0	29.0
Seawalls	2.0	1.0	1.0	4.0
Beach Replenishment	1.0	2.0	0	3.0
Beach Development	0	5.0	15.0	20.0

TABLE SC-2
SOUTH COASTAL SUBREGION
Estimated Average Annual Shoreline Erosion Damages and Damage Reduction through Shoreline Program, in $1,000 (1965 prices)

Item	Ventura County	Los Angeles County	Orange County	San Diego County	Subregion
Average annual damage, 1965	680	860	2,310	1,360	5,210
Average annual damage by 1980 with no shoreline program	1,090	1,240	4,000	2,270	8,600
Reduction in damage with 1966 to 1980 shoreline program					
Structural measures	500	70	2,000	220	2,790
Non-structural measures	280	370	660	810	2,120
Program total	780	440	2,660	1,030	4,910
Residual annual damage in 1980	310	800	1,340	1,240	3,690
Average annual damage by 2000 with no shoreline program after 1980	570	1,260	2,510	2,280	6,620
Reduction in damage with 1981 to 2000 shoreline program					
Structural measures	310	100	1,200	120	1,730
Non-structural measures	140	450	570	1,080	2,240
Program total	450	550	1,770	1,200	3,970
Residual annual damage in 2000	120	710	740	1,080	2,650
Average annual damage by 2020 with no shoreline program after 2000	250	1,090	1,070	1,700	4,110
Reduction in damage with 2001 to 2020 shoreline program					
Structural measures	120	40	150	40	350
Non-structural measures	70	370	500	930	1,870
Program total	190	410	650	970	2,220
Residual annual damage in 2020	60	680	420	730	1,890
Estimated annual damage in 2020 with no shoreline program after 1965	4,030	3,020	10,420	6,550	24,020
Total reduction in annual damage due to 1966 to 2020 shoreline program	3,970	2,340	10,000	5,820	22,130

TABLE SC-3
SOUTH COASTAL SUBREGION
Estimated Recreational Shoreline Needed, and Recreational Shoreline Made Available by the Program, in Miles

Item	Ventura County			Los Angeles County			Orange County			San Diego County			Total subregion		
	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline
Available in 1965	22.7	0.9	13*	20.8	0.4	10*	22.0	0	0	17.5	0	4	83.0	1.3	27
Needed by 1980	3.4	0.3	-	38.3	1.6	-	17.4	0.2	-	7.9	0.9	-	67.0	3.0	-
Deficiency (-) or surplus (+)	+19.3	+0.6	-	-17.5	-1.2	-	+4.6	-0.2	-	+9.6	-0.9	-	+16.0	-1.7	-
1966-1980 program supply	0	0	0	0	0.2	0	0	0.2	0	3.3	0	0	3.3	0.4	0
Available in 1980 with program	22.7	0.9	3	20.8	0.6	0	22.0	0.2	0	20.8	0	4	86.3	1.7	7
Needed by 2000	8.4	0.3	-	47.2	3.2	-	26.4	0.3	-	13.0	1.2	-	95.0	5.0	-
Deficiency (-) or surplus (+)	+14.3	+0.6	-	-26.4	-2.6	-	-4.4	-0.1	-	+7.8	-1.2	-	-8.7	-3.3	-
1981-2000 program supply	0	0	0	5.0	0	0	0	0	0	9.7	0	0	14.7	0	0
Available in 2000 with program	22.7	0.9	3	25.8	0.6	0	22.0	0.2	0	30.5	0	4	101.0	1.7	7
Needed by 2020	14.8	0.3	-	54.8	4.0	-	33.8	0.4	-	17.6	1.3	-	121.0	6.0	-
Deficiency (-) or surplus (+)	+7.9	+0.6	-	-29.0	-3.4	-	-11.8	-0.2	-	+12.9	-1.3	-	-20.0	-4.3	-
2001-2020 program supply	0	0	0	15.0	0	0	0	0	0	0	0	0	15.0	0	0
Available in 2020 with program	22.7	0.9	3	40.8	0.6	0	22.0	0.2	0	30.5	0	4	116.0	1.7	7
Needed by 2020	14.8	0.3	-	54.8	4.0	-	33.8	0.4	-	17.6	1.3	-	121.0	6.0	-
Deficiency (-) or surplus (+) at end of program	+7.9	+0.6	-	-14.0	-3.4	-	-11.8	-0.2	-	+12.9	-1.3	-	-5.0	-4.3	-

* Includes 10 miles of scenic shoreline on Channel Islands

TABLE SC-4

SOUTH COASTAL SUBREGION

Estimated Shoreline Program Costs, in $1,000 (1965 prices)

1966-1980 PROGRAM

Item	Ventura County	Los Angeles County	Orange County	San Diego County	Subregion Total
STRUCTURAL MEASURES:					
Installation costs					
Federal	1,100	1,400	2,000	700	5,200
Non-Federal	1,100	1,400	2,000	700	5,200
Subtotal	2,200	2,800	4,000	1,400	10,400
Annual OM & R					
Federal	0	0	0	0	0
Non-Federal	22	28	40	14	104
Subtotal	22	28	40	14	104
NON-STRUCTURAL MEASURES:					
Installation costs					
Federal	0	0	0	0	0
Non-Federal	40	770	640	80	1,530
Subtotal	40	770	640	80	1,530
Annual OM & R					
Federal	0	0	0	0	0
Non-Federal	0	0	0	0	0
Subtotal	0	0	0	0	0
1966-1980 PROGRAM					
Federal	1,100	1,400	2,000	700	5,200
Non-Federal	1,140	2,170	2,640	780	6,730
Total	2,240	3,570	4,640	1,480	11,930
Annual OM & R	22	28	40	14	104

Continued

TABLE SC-4--Continued

SOUTH COASTAL SUBREGION

Estimated Shoreline Program Costs, in $1,000 (1965 prices)

1981-2000 PROGRAM

Item	Ventura County	Los Angeles County	Orange County	San Diego County	Subregion Total
STRUCTURAL MEASURES:					
Installation costs					
Federal	1,300	2,000	2,400	800	6,500
Non-Federal	1,300	7,000	2,400	800	11,500
Subtotal	2,600	9,000	4,800	1,600	18,000
Annual OM & R					
Federal	0	0	0	0	0
Non-Federal	26	90	48	80	244
Subtotal	26	90	48	80	244
NON-STRUCTURAL MEASURES:					
Installation costs					
Federal	0	0	0	0	0
Non-Federal	40	70	40	80	230
Subtotal	40	70	40	80	230
Annual OM & R					
Federal	0	0	0	0	0
Non-Federal	0	0	0	0	0
Subtotal	0	0	0	0	0
1981-2000 PROGRAM					
Federal	1,300	2,000	2,400	800	6,500
Non-Federal	1,340	7,070	2,440	880	11,730
Total	2,640	9,070	4,840	1,680	18,230
Annual OM & R	26	90	48	80	244

Continued

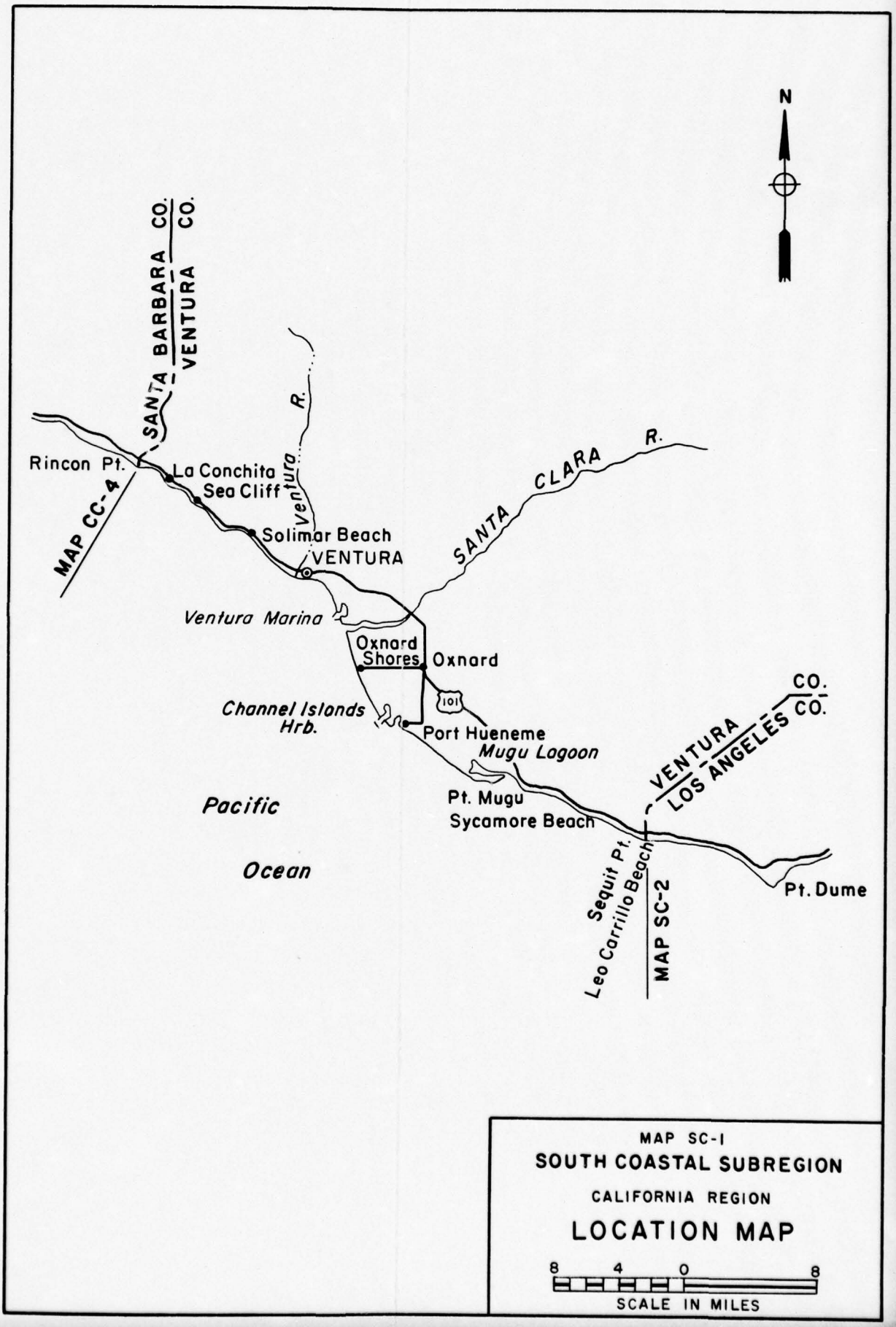
TABLE SC-4--Continued

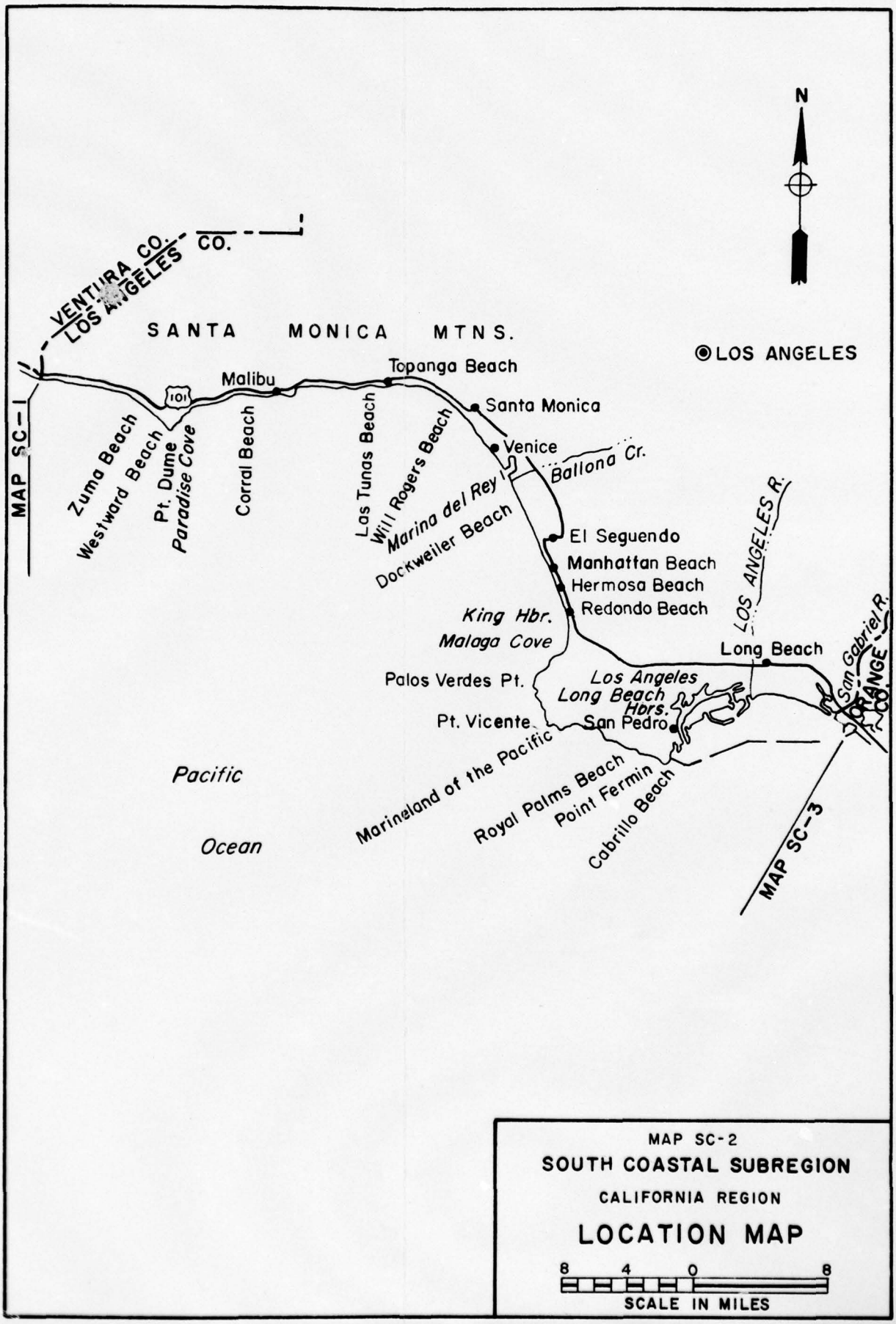
SOUTH COASTAL SUBREGION

Estimated Shoreline Program Costs, in $1,000 (1965 prices)

2001-2020 PROGRAM

Item	Ventura County	Los Angeles County	Orange County	San Diego County	Subregion Total
STRUCTURAL MEASURES:					
Installation costs					
Federal	300	800	800	400	2,300
Non-Federal	300	15,800	800	400	17,300
Subtotal	600	16,600	1,600	800	19,600
Annual OM & R					
Federal	0	0	0	0	0
Non-Federal	6	166	16	8	196
Subtotal	6	166	16	8	196
NON-STRUCTURAL MEASURES:					
Installation costs					
Federal	0	0	0	0	0
Non-Federal	40	70	40	80	230
Subtotal	40	70	40	80	230
Annual OM & R					
Federal	0	0	0	0	0
Non-Federal	0	0	0	0	0
Subtotal	0	0	0	0	0
2001-2020 PROGRAM					
Federal	300	800	800	400	2,300
Non-Federal	340	15,870	840	480	17,530
Total	680	16,670	1,640	880	19,830
Annual OM & R	6	166	16	8	196


N
SANTA BARBARA CO.
VENTURA CO.
Ventura R.
Rincon Pt.
La Conchita
Sea Cliff
MAP CC-4
Solimar Beach
VENTURA
SANTA CLARA R.
Ventura Marina
Oxnard Shores
Oxnard
101
Channel Islands Hrb.
Port Hueneme
Mugu Lagoon
VENTURA CO.
LOS ANGELES CO.
Pacific
Ocean
Pt. Mugu
Sycamore Beach
Sequit Pt.
Leo Carrillo Beach
MAP SC-2
Pt. Dume
MAP SC-1
SOUTH COASTAL SUBREGION
CALIFORNIA REGION
LOCATION MAP
8 4 0 8
SCALE IN MILES



MAP SC-2

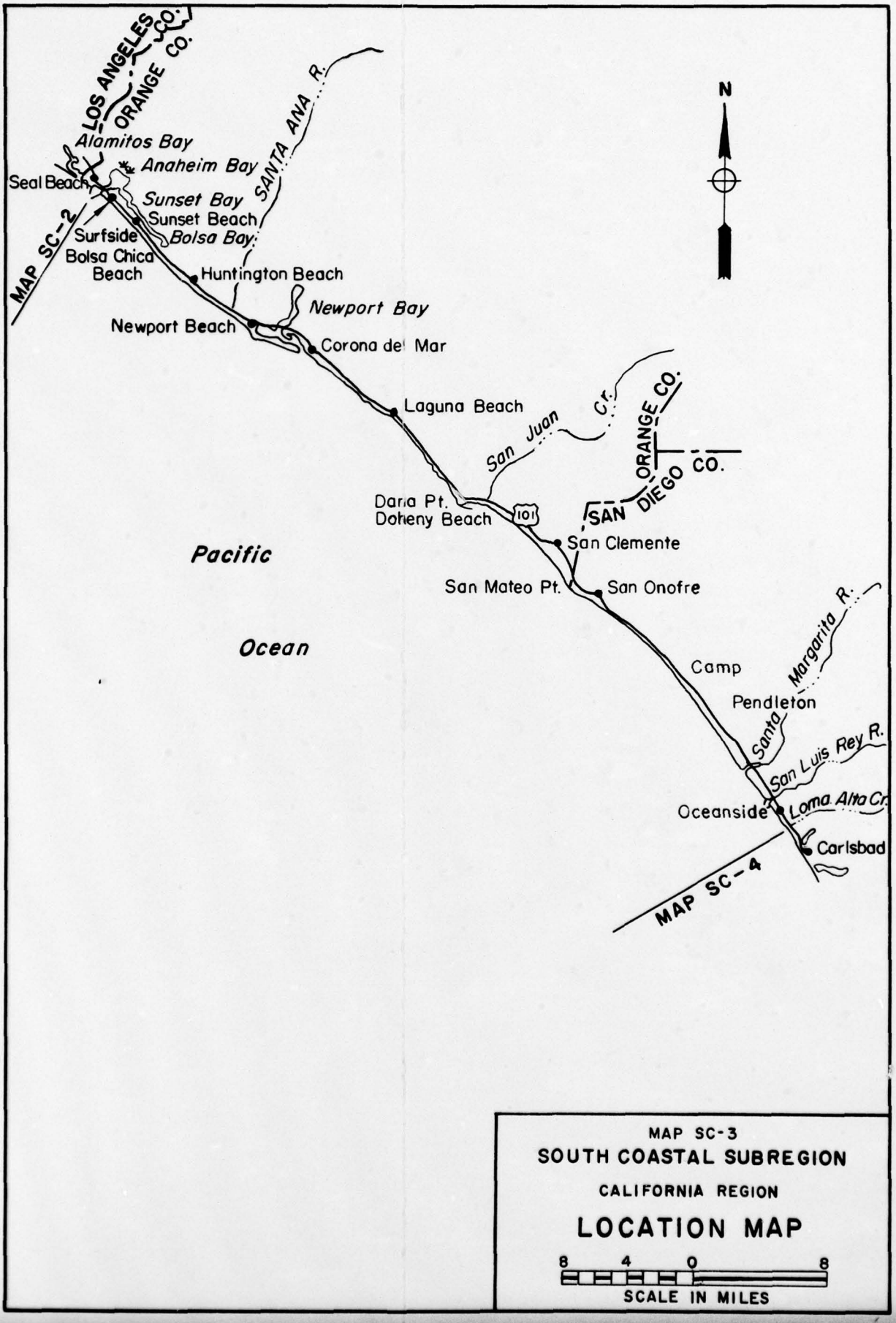
SOUTH COASTAL SUBREGION

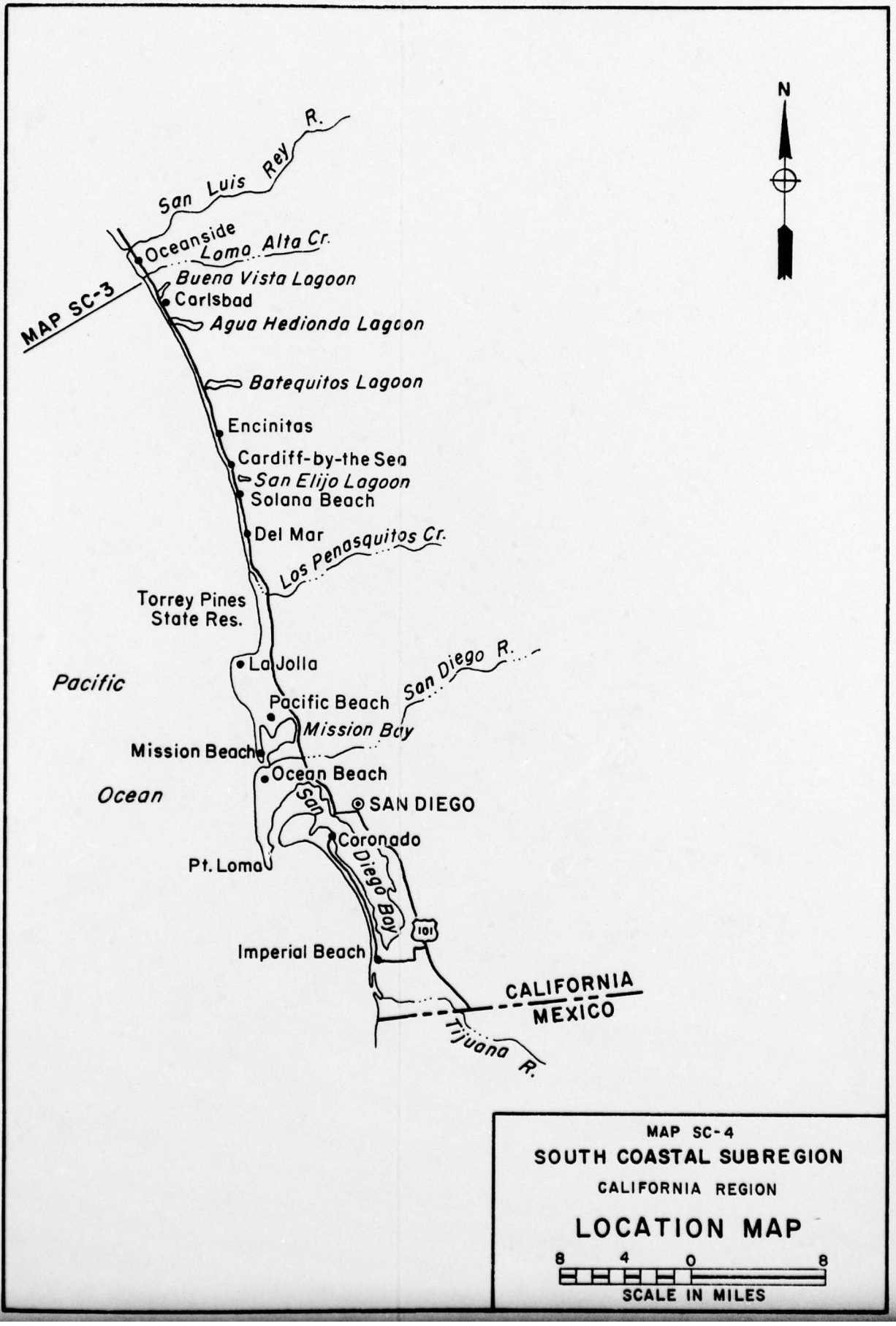
CALIFORNIA REGION

LOCATION MAP

8 4 0 8

SCALE IN MILES


LOS ANGELES CO.
ORANGE CO.
Alamitos Bay
Anaheim Bay
SANTA ANA R.
Seal Beach
Sunset Bay
Sunset Beach
Surfside
Bolsa Bay
Bolsa Chica Beach
MAP SC-2
Huntington Beach
Newport Bay
Newport Beach
Corona del Mar
Laguna Beach
San Juan Cr.
ORANGE CO.
SAN DIEGO CO.
Dana Pt.
Doheny Beach
101
San Clemente
Pacific
Ocean
San Mateo Pt.
San Onofre
Camp Pendleton
Santa Margarita R.
San Luis Rey R.
Oceanside
Loma Alta Cr.
Carlsbad
MAP SC-4
N
MAP SC-3
SOUTH COASTAL SUBREGION
CALIFORNIA REGION
LOCATION MAP
8 4 0 8
SCALE IN MILES


N
San Luis Rey R.
Oceanside
Loma Alta Cr.
Buena Vista Lagoon
Carlsbad
MAP SC-3
Agua Hedionda Lagoon
Batequitos Lagoon
Encinitas
Cardiff-by-the Sea
San Elijo Lagoon
Solana Beach
Del Mar
Los Penasquitos Cr.
Torrey Pines State Res.
La Jolla
Pacific
San Diego R.
Pacific Beach
Mission Bay
Mission Beach
Ocean Beach
Ocean
San
SAN DIEGO
Coronado
Pt. Loma
Diego Bay
101
Imperial Beach
CALIFORNIA
MEXICO
Tijuana R.
MAP SC-4
SOUTH COASTAL SUBREGION
CALIFORNIA REGION
LOCATION MAP
8 4 0 8
SCALE IN MILES

SUPPLEMENTS

SUPPLEMENT A

ALTERNATIVE PROJECTIONS

Effects of OBERS Projections on the Shoreline Program

The principal effects of March 1968 OBERS projections upon estimates of future needs for shoreline protection and development would be to increase deficiencies in recreational beaches in the South Coastal subregion and to increase travel time to recreational shoreline available to the Region's residents.

The shoreline zone characteristically has become saturated with urban improvements at a more accelerated rate than have inland areas, and shoreline properties have sold at consistently higher prices than similar inland property. Control of urban encroachment into the shoreline zone, through a management program such as that recommended as a non-structural measure for protection, would limit future encroachments, regardless of the regional population distribution. Potential damages to urban developments and recreational beaches would not be significantly affected by economic indices relating to the OBERS projections.

Further, the needs for preservation and conservation of scenic shoreline, as set forth in this appendix, are independent of regional population distributions. The needs for recreational beaches were developed with consideration given to local tributary area requirements, regional tourism and tourism from other areas of the nation. The subregion most severely affected by the OBERS projections is the South Coastal subregion. This appendix proposes a maximum development of recreational beaches in that subregion. It is doubtful if additional beaches could be developed. Under the OBERS projections, the increased demand for swimming beaches and non-swimming beaches in the South Coastal would result in an increased unmet demand.

The reduced local requirements in the North Coastal, San Francisco Bay and Central Coastal subregions would permit less intensive use of beaches in these areas and would increase the quality of the recreational facility. These beaches would also be available to residents of the South Coastal subregion for weekend and vacation use.

The overall effects of the OBERS projection are summarized in Table A-1. The indicated program is based on full satisfaction of local needs for all counties within each subregion, except in the South Coastal subregion, where considerable local and subregional need cannot be met. The program also supplies beaches in the North Coastal, San Francisco Bay and Central Coastal subregions to satisfy both regional and national tourism.

Effects of 1970 Series D Projections on the Shoreline Program

The 1970 Series D projection is essentially a combination of Base Plan and OBERS projections. The overall needs for recreational beaches in the Region would be reduced, however recreational beach needs in the South Coastal subregion would still outstrip supply.

Needs for preservation and conservation of scenic shoreline would not be affected, nor would potential erosion damages. The rationale for this statement is presented in the preceding statement on the effects of OBERS projections.

Needs for recreational beaches were developed with consideration given to local tributary areas requirements, regional tourism and tourism from other areas of the nation. The reduced local requirements in the North Coastal, San Francisco Bay and Central Coastal subregions would permit less intensive use of beaches in these areas and would increase the quality of the recreational facility. These beaches would also be available to residents of the South Coastal subregion for weekend and vacation use.

The overall effects of the 1970 Series D projection are summarized in Table A-2. The indicated program is based on full satisfaction of local needs for all counties within each subregion, except in the South Coastal subregion, where some local needs cannot be met. The program also supplies beaches in the North Coastal, San Francisco Bay and Central Coastal subregions to satisfy both region and national tourism.

TABLE A-1

OBERS PROJECTION
CALIFORNIA REGION
Estimated Recreational Shoreline Needed, and Recreational Shoreline Made Available by the Program, in Miles

Item	North Coastal Subregion			San Francisco Bay Subregion			Central Coastal Subregion			South Coastal Subregion			Region Total		
	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline
Available in 1965	0	14.0	32.0	4.0	49.0	31.0	19.9	25.9	6.0	83.0	1.3	27.0	106.9	90.2	96.0
Needed by 1980	0	5.0	-	7.0	24.0	-	6.0	7.0	-	70.0	3.0	-	83.0	39.0	-
Deficiency (-) or surplus (+)	0	+9.0	-	-3.0	+25.0	-	+13.9	+18.9	-	+13.0	-1.7	-	+23.9	+51.2	-
1966-1980 program supply	0	3.0	36.0	3.0	13.0	34.0	1.2	0	176.0	3.3	0.4	0	7.5	16.4	246.0
Available in 1980 with program	0	17.0	68.0	7.0	62.0	65.0	21.1	25.9	182.0	86.3	1.7	27.0	114.4	106.6	342.0
Needed by 2000	0	7.0	-	9.0	33.0	-	9.0	10.0	-	110.0	6.0	-	128.0	50.0	-
Deficiency (-) or surplus (+)	0	+10.0	-	-2.0	+29.0	-	+12.1	+15.9	-	-23.7	-4.3	-	-13.6	+50.6	-
1981-2000 program supply	0	1.0	28.0	4.0	2.0	0	1.8	0.1	51.0	14.7	0	0	20.5	3.1	79.0
Available in 2000 with program	0	18.0	96.0	11.0	64.0	65.0	22.9	26.0	233.0	101.0	1.7	27.0	134.9	109.7	421.0
Needed by 2020	0	10.0	-	13.0	46.0	-	14.0	13.0	-	160.0	8.0	-	187.0	77.0	-
Deficiency (-) or surplus (+)	0	+8.0	-	-2.0	+18.0	-	+8.9	+13.0	-	-59.0	-6.3	-	-52.1	+32.7	-
2001-2020 program supply	0	1.0	5.0	5.0	2.0	0	2.8	0.3	0	15.0	0	0	22.8	3.3	5.0
Available in 2020 with program	0	19.0	101.0	16.0	66.0	65.0	25.7	26.3	233.0	116.0	1.7	27.0	157.7	113.0	426.0
Needed by 2020	0	10.0	-	13.0	46.0	-	14.0	13.0	-	160.0	8.0	-	187.0	77.0	-
Deficiency (-) or surplus (+) at end of program	0	+9.0	-	+3.0	+20.0	-	+11.7	+13.3	-	-44.0	-6.3	-	-29.3	+36.0	-

TABLE A-2

1970 SERIES D PROJECTION
CALIFORNIA REGION

Estimated Recreational Shoreline Needed, and Recreational Shoreline Made Available by the Program, in Miles

Item	North Coastal Subregion			San Francisco Bay Subregion			Central Coastal Subregion			South Coastal Subregion			Region Total		
	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline	Swimming beach	Non-swimming beach	Scenic shoreline
Available in 1965	0	14.0	32.0	4.0	49.0	31.0	19.9	25.9	6.0	83.0	1.3	27.0	106.9	90.2	96.0
Needed by 1980	0	5.0	-	7.0	24.0	-	6.0	7.0	-	67.0	3.0	-	80.0	39.0	-
Deficiency (-) or surplus (+)	0	+9.0	-	-3.0	+25.0	-	+13.9	+18.9	-	+16.0	-1.7	-	+26.9	+51.2	-
1966-1980 program supply	0	3.0	36.0	3.0	13.0	34.0	1.2	0	176.0	3.3	0.4	0	7.5	16.4	246.0
Available in 1980 with program	0	17.0	68.0	7.0	62.0	65.0	21.1	25.9	182.0	86.3	1.7	27.0	114.4	106.6	342.0
Needed by 2000	0	7.0	-	9.0	33.0	-	9.0	10.0	-	95.0	5.0	-	113.0	55.0	-
Deficiency (-) or surplus (+)	0	+10.0	-	-2.0	+29.0	-	+12.1	+15.9	-	-8.7	-3.3	-	+1.4	+51.6	-
1981-2000 program supply	0	1.0	28.0	4.0	2.0	0	1.8	0.1	51.0	14.7	0	0	20.5	3.1	79.0
Available in 2000 with program	0	18.0	96.0	11.0	64.0	65.0	22.9	26.0	233.0	101.0	1.7	27.0	134.9	109.7	421.0
Needed by 2020	0	10.0	-	13.0	46.0	-	14.0	13.0	-	121.0	6.0	-	148.0	75.0	-
Deficiency (-) or surplus (+)	0	+8.0	-	-2.0	+18.0	-	+8.9	+13.0	-	-20.0	-4.3	-	-13.1	+34.7	-
2001-2020 program supply	0	1.0	5.0	5.0	2.0	0	2.8	0.3	0	15.0	0	0	22.8	3.3	5.0
Available in 2020 with program	0	19.0	101.0	16.0	66.0	65.0	25.7	26.3	233.0	116.0	1.7	27.0	157.7	113.0	426.0
Needed by 2020	0	10.0	-	13.0	46.0	-	14.0	13.0	-	121.0	6.0	-	148.0	75.0	-
Deficiency (-) or surplus (+) at end of program	0	+9.0	-	+3.0	+20.0	-	+11.7	+13.3	-	-5.0	-4.3	-	+9.7	+38.0	-

SUPPLEMENT B

GLOSSARY

BEACH	The zone of unconsolidated material that extends landward from the low water line to the place where there is marked change in material or physiographic form.
BEACH ACCRETION	May be either natural or artificial. Natural accretion is the gradual buildup of land over a long period of time solely by the action of the forces of nature. Artificial accretion is a similar buildup of land by reason of an act of man, such as the accretion formed by groin, breakwater or beach fill deposited by mechanical means.
BEACH BACKSHORE	That zone of the shore or beach lying between the foreshore and the coastline and acted upon by waves only during severe storms.
BEACH BERM	A nearly horizontally portion of the beach or backshore formed by the deposit of material by wave action.
BEACH EROSION	The carrying away of beach materials by wave actions, tidal currents, littoral currents or wind.
BEACH FORESHORE	The portion of the shore lying between the crest of the seaward berm and the ordinary low water mark.
CONTINENTAL SHELF	The zone bordering a continent, extending from the line of permanent immersion to the depth (usually about 100 fathoms) where there is a marked or rather steep descent toward the greater depths.
DOWNCOAST, UPCOAST	In United States usage, downcoast is the coastal direction generally trending toward the south and upcoast is the coastal direction generally trending toward the north.

ENCROACHMENT	Development and growth in the shoreline zone that create an erosion damage potential. Encroachment includes, but is not limited to, buildings, streets, structures, and plant growth resulting from changes in land-use patterns.
GROIN	A shore protective structure (usually built perpendicular to the shoreline) to trap littoral drift or retard erosion of the shore.
INSTALLATION COST	The value of goods and services necessary for the establishment of the project; including initial project construction, lands, easements, rights-of-way and water rights; capital outlays to relocate facilities or prevent damages, and all other expenditures for investigations and surveys and designing, planning, and constructing a project after its authorization (excludes interest during construction). Also called project first costs.
JETTY	A structure extending into the body of water on estuaries or open seacoasts which is designed to prevent shoaling of a channel by littoral materials and to direct or confine stream or tidal flow.
LITTORAL CURRENT	The nearshore current primarily due to wave action.
LITTORAL TRANSPORT	The movement of material along the shore in the littoral zone by waves and currents.
MEAN HIGH WATER	In respect to tides, the average height of the high waters over a 19-year period. All high water heights are included in the average where the type of tide is either semidiurnal or mixed. Only the higher high water is included in the average where the type of tide is diurnal. SEE TIDE.

MEAN HIGHER HIGH WATER	The average height of the higher high waters.
MEAN LOW WATER	The average height of the low waters.
MEAN LOWER LOW WATER	The average height of the lower low waters.
MEAN TIDE LEVEL	A plane midway between mean high water and mean low water.
OPERATION, MAINTENANCE, AND REPLACEMENT COSTS (OM & R)	The value of goods and services needed to operate a constructed project and make repairs and replacements necessary to maintain the project in sound operating condition during its economic life.
REQUIREMENTS	The goods, services or resources necessary to fulfill a specified projection. The willingness or capability of the sector of economy to satisfy the projection is not a factor in requirements.
SERVICE AREA	The geographic area served by the function under discussion. Also called tributary area.
TIDE	The periodic rising and falling of the water that results from gravitational attraction of the moon and sun acting upon the rotating earth.
TIDE, DIURNAL	A tide with one high water and one low water in a tidal day.
TIDE, MIXED	A type of tide in which the presence of a diurnal wave is conspicuous by a large inequality in either the high or low water heights with two high waters and two low waters usually occurring each tidal day.
TIDE, SEMIDIURNAL	A tide with two high and two low waters in a tidal day, with comparatively little diurnal inequality.
TOMBOLO	An area of unconsolidated material deposited by wave action or currents that connects an island to the mainland or to another island. An island-tying spit.

TSUNAMI	A long-period wave caused by an underwater seismic disturbance such as volcanic eruption or earthquake, commonly misnamed "tidal wave".
WETLANDS	Low-lying areas that are usually covered with shallow or intermittent water. Often referred to as marshland, swamp, sloughs or lagoons.

SUPPLEMENT C

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